For happier generations...
For productivity and creativity...
For a better world...

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Female Legends of Science Project Guideline

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Foreword

It was in 2019 when the Females Legends of Science Project admitted by Turkish National Agency. That means it was three years before in which we had a long story. We had a long story because during this time we had losts, we had newcomers and we faced to COVİD-19 which were all improtant events for our life.

What happened during this time? We lost one of our partner, Eliza from Romania. Eliza, we know that you watch us and you can rest in peace, we succeed. We also had six babies; three form Turkey and three from Greece. Serdar, Oğuz, Asaf and the others...Dear babies, we are working for providing you a better world so trust in us! We faced Covid-19 and had a huge trauma that we couldn't go out, travel or see the ones that we care. Even in Covid-19 times, we went on working without stopping. So this is the result. The book that you are trying to read now was prepared in the scope of FEMALES project which has six partners from five different countries; Turkey, Greece, Italy, Romania and Spain. With the leading of Bahcesehir University; Sukran Ulgezen Technical and Vocational Anatolian High School from Turkey; Challedu from Greece; AİJU from Spain; Euphoria.Net from Italy and CASA Curpului Dicactic Teleorman from Romania.

Our aim is to create innovative tools for role-model education and fight to stereotypes and gender discrimination in the field of STEM. While doing this, we try to be creative, productive and innovative. So we created this quideline which was formed by six chapters, one cooperative card game about female scientists, an activity book, an e-book that includes activities, augmented reality app and an online learning platform which includes all these information, games and videos .

Foreword

We hope that you like and benefit this resource especially for the social part of STEM or STEAM education. We believe in that women scientists are good role models for our new generation and if we can scrutinize their life, we can give the message to new generation that; if you want to be successful, there will be always challenges. The main thing is that to struggle with all these challenges and recover from them. So we should be brave, we should be hardworking and we should be persevering.

For giving all these messages, we used games and gamification as a learning-teaching approach and we created an e-learning platform that the teachers can benefit. If you would like to learn more about FEMALES PROJECT; you can reach our website and e-learning platform from https://www.femalesproject.eu/.

With this book,our aim is to give all the details regarding to STEM education,women's situation in STEM fields, STEM materials, role model in STEM education and gamification in STEM. We hope that it can reach its aim.

Enjoy reading...

Ayşin KAPLAN SAYI

Theoretical Framework

1.1. An Overview of STEM

Defined as the integration of science, technology, engineering and mathematics, STEM is a learning approach that eliminates the traditional viewpoint separating the aforementioned disciplines and integrates them with real world learning experiences for students (Vasquez, Sneider & Comer, 2013). STEM, which was coined in 1990's, serves as a milestone and relates to a paradigm shift in the sense that several countries have used it to restructure their education systems and prepare their students for their future careers (Ruff, 2017). STEM concentrates mostly on science and mathematics disciplines but includes technology and engineering, as well. It is an approach that encourages students to learn directly, helps students fulfil their dreams and enables them to transfer what they learn to new and different learning environments. Focusing on the integrity of science, technology, engineering, and mathematics knowledge and skills, STEM enables students to cultivate their skills in problem solving, to use their creativity, to engage in interdisciplinary cooperation, and to be effective in the fields of communication and entrepreneurship (Thomas, 2014).

Through application-based, problem-focused activities, STEM education aims to help students develop cognitive and critical thinking skills through finding solutions to problems using their knowledge and skills in science, mathematics and technology. Teachers that are working in STEM areas make use of natural and active exchanges of knowledge, skills, and beliefs among four disciplines with a flexible approach to teach the subjects in their natural context without separating the disciplines with rigid boundaries (Çorlu, Capraro, & Capraro, 2014).

1.1.An Overview of STEM

While doing so, they also utilize required 21st century knowledge and skills, which includes activities that will enable them to focus on science, technology, engineering and mathematics in an elaborative manner (Baran, Canbazoğlu-Bilici, Mesutoğlu, 2015). This enables both teachers and students focus on skills such as critical thinking, creativity, communication, and collaboration, which, as Çorlu (2013) implies, is also a demand of 21st century economies to foster interdisciplinary knowledge, skills, and values that are germane to real life skills and requirements.

Countries that focus on the production of information and technology attaches more importance to STEM education to improve students' skills accordingly. In the studies conducted so far, it has been found out that countries such as USA, England, Japan that integrate STEM education in the education system have grown economically and there has been an increase in students' achievement in international exams such as PISA and TIMSS (Acar, 2018). In addition, European universities attempt to establish STEM departments aligned with the goals set by the European Commission, to meet standards by focusing on the question how students might be prepared to be skilled, engaged, and self-regulated innovators and how such skills can be assessed (Harmsen, 2015; Çorlu, 2013).

1.2.The Position of Women in STEM Areas

Societal beliefs and the learning environment have strong effects on girls' achievements and interest in science and math. When they are inculcated in their intelligence and potential by both their teachers and parents, they are more likely to produce tangible outcomes (Hill, Corbett, & Rose, 2010). Similar to other areas, there is a huge gender gap in STEM areas against girls in many parts of the world (Magwood, 2017; PwC, 2017). In spite of the progress over the past decades, women remain under-represented in STEM areas. Although female students do well in so-called areas, especially in math and science, they often prefer to proceed in a different career path. According to Wood (2020), only 30 % of researchers in STEM areas is women all around the world. Many countries are struggling to fill this gap and are developing policies to reverse this ongoing trend as more and more workforce will be necessary in STEM areas and there will be a demand for skilled workers in the aforementioned areas (Magwood, 2017).

As it is a well-known fact, female students and employees are underrepresented in STEM areas. Along with this fact, one third of female students proceed to higher education in subjects like math and engineering and women working in STEM areas publish less and often receive less pay (Wood, 2020).

When we consider high school achievement, boys made better than girls in math in the past, but in recent years the gender gap has narrowed, and girls are doing as well as boys in math on average (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). When it comes to the transition from high school to college, statistics show that many young women prefer not to continue in STEM career paths.

1.2.The Position of Women in STEM Areas

Of the total number of students in the college, women constitute the majority; however, they are less in number than their male peers to study for a bachelor's degree in STEM areas. Moreover, their representation in groups studying for a doctoral degree is also below the expectations although there has been an increase in the number of female PhD students in STEM disciplines (Hill et al., 2010).

prefer not to continue in STEM career paths.

Woman in workforce in STEM areas is also underrepresented in spite of the steady increase in the statistics. According to a study conducted by PwC (2017), females are less likely to pursue a career in STEM areas. Among the reasons why women prefer not to work in these areas can be mentioned as (1) their better grades in other areas, (2) not finding STEM areas interesting, (3) STEM topics being irrelevant to their career choices, (4) uninteresting learning environments that do not attract their attention, and (5) the need for achieving high grades to succeed in university entrance exams. In addition, Magwood (2017) signals the existence of discrimination against women in the workforce and the societies' expectations of women to care for family, and therefore interrupting their work for family and household issues.

1.3. Stereotypes in STEM Areas

In male-dominated fields women frequently face implicit as well as explicit stereotypes. According to role congruity theory, stereotypes originate from observing people in the social roles that they typically occupy. As a result of the fact that men have traditionally occupied and positions in STEM areas, people generally associate these areas with masculine figures, wearing glasses and working in laboratories. As a result of this association, women are regarded as unsuitable figures to match with STEM and are likely to be treated negatively when occupy position. Women are generally believed that they are less likely to succeed, to get promoted, and occupy a leader position in sectors where there is male dominance (Meyer, Cimpian, & Leslie, 2015). This is also worth emphasizing that women who succeed in a way despite all negative views usually experience reaction for not performing their socially prescribed duties. It is also a striking fact that women in management positions typically have less authority, and receive fewer rewards and are paid less compared to their male counterparts (Lips, 2015).

1.4.The Reasons for Underrepresentation of Women in STEM Areas

Stereotype Threat

As mentioned before, women in STEM areas unfortunately face inaccurate and derogatory assumptions about their skills in both educational background and career pursuits. These threatening experiences can lead to women's low self-efficacy and self-imposed isolation (Picho, 2016). When they become aware of these ubiquitous inaccuracies, they might fear confirming these unfair beliefs, and they might underperform, as a result. Fear of confirming negative stereotypes (e.g., women are worse at math than men) can be described as stereotype threat (Steele, Spencer, & Aronson, 2002). Ongoing research has shown that unless gender expectations are consistent with field norms, women will less likely to persevere and achieve success (Stephens, Fryberg, Markus, Johnson, & Covarrubias, 2012).

Lack of Interest

Many studies that are conducted to examine the reasons why women are underrepresented concludes with the finding that males show higher interest in working with objects while women were more interested in working with people (Rounds & Armstrong, 2009). Men are referred as individuals who has little interest in people and singular focus in computer science while women get more interested in arts or communication-based areas. Although different at the beginning, women start showing less interest in computer-related task such as programming and coding, by which it becomes more and more difficult to retain their attention in STEM.

1.4.The Reasons for Underrepresentation of Women in STEM Areas

Lack of Interest

In a study conducted in Canada, it was found that even high level of mathematical ability was not predictor of a choice in STEM areas for women whereas men with less mathematical ability were more likely to enter STEM areas (Hango, 2013).

Lack of Role Models

Because of the aforementioned reasons, women are underrepresented in STEM areas and this results in a scarcity of STEM female role models who can easily be noticed and followed by female students. As PwC (2017) suggests, females are more committed to change the world to make a better place to live and they are in search of a career opportunity that will enable to make this positive contribution. Their working in STEM areas can help them take initiatives to satisfy desires and to be encourages to these areas, they need real role models who have already fulfilled their dreams by working in these areas. Hills et al. (2010) implies that the depiction of successful female role models can help females realize that people like them can be successful and in this way, stereotype threat can also be managed and overcome.

1.5.Studies in the Literature Related to STEM

Bircan (2019) in his research study focused on the use of STEM activities with and Grade 4 students at primary school investigated students' perceptions towards STEM and the effect of their perception on 21st-century skills and their achievement levels in mathematics. This mixed-methods study utilized an explanatory sequential design. In the quantitative component of the study, a time- series design was used as a quasi-experimental design type. The study group consisted of 34 Grade 4 students at primary school. The quantitative data were collected through the STEM Attitude Scale, 21st Century Creativity and Renewal Skills Scale, Scratch Achievement Test, and Mathematics Achievement Test. The qualitative data were collected through a semi-structured interview form. Descriptive statistics, repeated measures ANOVA, and dependent samples t-test were used for analyzing quantitative data. The qualitative data were analyzed through descriptive analysis and content analysis. The results showed that the STEM training had a significant effect on the perceptions of Grade 4 students and their 21st-century skills. It was also found that the effect of the STEM training on improving the achievement levels of Grade 4 students was not significant. The students stated that STEM activities were fun, useful, and informative. They also indicated that STEM activities had a positive effect on their attitudes towards natural sciences, technology, engineering, and mathematics and improved their 21st-century skills such as communication, collaboration, creativity, and critical thinking.

1.5.Studies in the Literature Related to STEM

Bitter (2019) aimed to examine the relationship between majoring in STEM and claimed self-handicapping among women. In addition, gender stigma consciousness and math identification were examined. The study was carried out through survey design. Data collection tools included Rosenberg Self-Esteem Scale (SES), the Positive and Negative Affect Schedule-Expanded Form (PANAS-X), as well as demographic and academic information. The collected data was analyzed through independent samples t-test. At the end of the study, it was concluded that females who are more aware of their gender's stigmatized status are more likely to claim self-handicap. Additionally, women who have greater awareness of their gender's stigma and find math valuable and important for their future success are more likely to claim self-handicaps prior to a threatening testing situation.

Doğan (2019) aimed to investigate the effect of STEM activities on academic success in science course, scientific process skills, science attitudes and STEM attitudes of the 7th grade students. In the study, pre-test post-test with control group experimental design was used. The study group consisted of 85 students in a secondary school in the Bursa in the 2016- 2017 academic year. While the control group students were taught with the teaching methods based on the current Science curriculum, the experimental group was taught with STEM integrated 5E model. SPSS program was used for the statistical analysis of quantitative data and the frequency-percentage values were calculated with content analysis for analyzing the qualitative data.

1.5.Studies in the Literature Related to STEM

The results of the study showed that there was a significant difference between the post test scores of the Electric Energy Success and STEM attitude in favor of the experimental group, while there was no significant difference in scientific process skills. In addition students in the experimental group stated that they enjoyed activities, their knowledge increased, and they could choose engineering as a profession in the future and they wanted to work with STEM education in other courses.

Grata (2019) aimed to investigate self-efficacy and STEM backgrounds of undergraduate female students who were currently in a 4-year STEM-related major within one university. By using quantitative case study research design, the researcher collected data with survey instrumented for this study. The participants included 69 university students, ranging from freshmen to senior. The collected data was analyzed through t-test. Findings of the study indicated that there was no difference between academic STEM classes and gender; males had higher self-efficacy than females; and there was one area of self-efficacy in females that stands higher among the four.

Jensen (2019) examined women full professors' strategies to cope with obstacles they experienced while advancing in academic STEM areas. The study was carried out through case study. The participants of the study included 13 full professors in STEM academic departments. Semi-structured interviews were used as part of data collection tools. The collected data were analyzed through content analysis.

1.5.Studies in the Literature Related to STEM

Findings of the study indicated that women professors were motivated for a promotion mainly because of the prestige, status and recognition that accompanies that promotion. Among the strategies mentioned by the professors, most important were understanding the criteria and standards for promotion, building academic references, focusing on research, adhering to research time, and establishing collaborations for doing research.

Khodos (2019) aimed to explore the manner in which social models impact women's STEM self-efficacy and interest. The study was carried out through experimental research design. With this design, 580 high school students studied the profiles of fictional scientists, all of which varied in gender, level of attractiveness, utilization of gendered language, and inclusion of a human element. The data of the study was collected with STEM self-efficacy test and STEM career interest test. The collected data were analyzed through ANOVA. The results demonstrated that the type of model and the type of message mattered. In addition, it was found out that students' STEM efficacy and interest respond to model manipulations.

Acar (2018) aimed to determine the effect of STEM education on the academic success in the science and math course, critical thinking and problem solving skills of the elementary 4th grade students. The research was designed as mixed method. The study group consists of three separate groups as Experimental 1, Experimental 2 and Control group of the 4th grade students in two different primary schools, which are in the similar socio-economic level and where students are equivalent in terms of science and mathematical success.

1.5.Studies in the Literature Related to STEM

While the lesson in the Experiment 1 and Experiment 2 groups was taught through lesson plans which had been prepared with STEM activities, the lesson in the control group was taught through textbooks and workbooks recommended by Ministry of National Education.

The data of the study was obtained by using “Science Academic Achievement Test”, “Mathematics Academic Achievement Test”, “Critical Thinking Skills Scale”, “Science Problem Solving Skills Assessment Instrument” and “Mathematics Problem Solving Skills Assessment Instrument”. However, a “Semi-Structured Interview Form” was used in order to identify the opinions of experimental group students about the process to obtain the qualitative data. ANOVA and frequency analysis, one of the content analysis techniques, were used to determine the opinions of the students about the process. At the end of the study, the researcher found out that STEM education is effective in improving the academic achievement, critical thinking and non- routine problem solving skills of primary school 4th grade students in Science and Mathematics courses.

Gilbert (2015) aimed to expose females to role models, to reduce explicit stereotypes and to strengthen women-science associations in the study that he conducted. The study was carried out through longitudinal experimental design. Participants of the study included 72 freshmen women. Participants read two role model biographies twice separately during the semester and they were asked to reflect upon the ways in which they associated themselves with the role model.

1.5.Studies in the Literature Related to STEM

They were also requested to include some facts about the role model and her hobbies. Data collection tools included Go/No-Go Association Task (GNAT), STEM Stereotype Endorsement Scale, Identification Scale, Sense of, STEM Degree Intentions Scale, Belonging Scale, and Role Model Identification Scale.Results showed that supporting women to associate themselves with a role model reduces the strength of explicit stereotypes and enhanced implicit women-science associations.

Ritzdorf (2015) explored the perceptions of women in STEM leadership roles and how they attained and maintained their leadership roles while they were exposed to stereotype threat. The study was carried out through phenomenological study. The participants were seven women from metropolitan cities working in STEM areas. The data were collected through personal narratives and one-to-one interviews. The collected data were content analyzed. The collected data was classified under three main headings: (1) the impact of stereotype threats on women in STEM careers; (2) the psychological situation of women in STEM careers; and (3) communication theories that are related to women in STEM leadership roles.

The descriptions of the women and their real life experiences provided insight about the fact that there were gender inequities and underrepresentation of women in STEM careers.

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1.5.Studies in the Literature Related to STEM

Brandt (2014) examined women's socio-cultural barriers such as low level of self-confidence, bias, and gender stereotypes in the study. The study was carried out through a cross-sectional online survey. With such as design the researcher aimed to evaluate the academic preparation, self-confidence, and cultural attitudes of undergraduate females who entered college to receive a bachelor's degree and continue in a STEM areas. A survey was used as a data collection tool. Descriptive analysis and ANOVA were used for data analysis. The results indicated that there was a strong academic preparation and a high level of self-confidence in women.

Petersen (2014) aimed to determine the perceived K-12 experiences that influenced females to look for a career in STEM areas. The study was carried out through qualitative design. 12 undergraduate students in the departments of Biology, Mathematics, or Physics were interviewed about their K-12 experiences. The interviews were analyzed through content analysis. At the end of the analysis, six themes were reached. Passion of teachers and features of classroom activities such as integrating challenging activities played an important role in the females' decisions to join STEM areas.

Extracurricular activities such as volunteering and mentoring and their desire to provide benefit to others influenced their career choice, as well. In addition, formal and informal opportunities helped them develop a sense of self- efficacy in STEM areas; this self-efficacy help them continue to pursue these career areas. Some of the participants referred to obstacles that they were faced with in K-12 education.

1.5.Studies in the Literature Related to STEM

These barriers were mainly internal as they tackled with overcoming personal barriers in learning and being competitive in mathematics and science classrooms.

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Theoretical Framework

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2.STEM Materials

2.1.Literature Review on STEM Materials

STEM literacy includes the integration of STEM disciplines and four interrelated components which requires the conceptual understandings, procedural skills and abilities for individuals. All these adress STEM-related personal, social, and global issues. In summary STEM literacy refers to the following:

• Learning about scientific, technological, engineering, and mathematical subjects and using that knowledge to identify issues, acquire new knowledge, and apply the knowledge to STEM-related issues.

• Understanding the characteristic features of STEM disciplines which include the processes of inquiry, design, and analysis.

• Recognizing how STEM disciplines shape our material, intellectual, and cultural world.

• Engaging in STEM-related issues and with the ideas of science, technology, engineering, and mathematics as concerned, affective, and constructive citizens.

Transferring this description of STEM literacy into school programs and instructional practices requires a way of organizing education so the respective disciplines can be integrated and instructional materials designed, developed, and implemented. Educators must confront and resolve a number of challenges if they are to advance STEM literacy (Bybee, 2010).

In literature integrative STEM education is emphasized. It includes to learn and teach at least two or more STEM subject areas an done or more school subjects (Sanders, 2009). In integrative STEM education inter-disciplinary work is emphasized. Because STEM should also be appropriate social and aesthetic contexts.

2.STEM Materials

2.1.Literature Review on STEM Materials

Becuase of this the pedagogy of “purposeful design and inquiry”is one of the essential elements of integrative STEM education. This pedagogy combines technological design with inquiry, engaging students or teams of students in scientific inquiry situated in the context of technological problem-solving—a robust learning environment. While planing the lessons and preparing the materials this pedagogy is the one that should be taken into consideration (Sanders, 2009).

Table 1. Integrative STEM phases and its relationship with STEM disciplines

Coupled inquiry	STEM disciplines
INQUIRY INVITATION Science content is introduced through a real world problem	SCIENCE - ENGINEERING Real world problem related to an engineering challenge
GUIDED INQUIRY Students perform guided experiment following teacher instruction	SCIENCE Application of scientific methodologies in order to address the scientific concepts needed to solve the problem MATHEMATICS Data analysis and interpretation TECHNOLOGY Handling of devices and instruments for the design of experiments, data gathering and analysis

2.STEM Materials

2.1.Literature Review on STEM Materials

Table 1. Integrative STEM phases and its relationship with STEM disciplines

Coupled inquiry	STEM disciplines
OPEN INQUIRY Students keep addressing the initial problem through experiments that are not guided by the teacher	SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS Students discuss the results obtained and they identify better ways to improve their design in order to solve the initial problem
INQUIRY RESOLUTION Solving the initial problem	ENGINEERING Students design or implement the technological device that solves the initial problem, using the scientific concepts developed previously and, in this way, linking engineering and science TECHNOLOGY Students propose possible technological applications in real world situations of the scientific concepts addressed throughout the inquiry. Students communicate their results and offer a possible resolution of the initial problem

(Toma and Greca, 2007).

2.STEM Materials

2.1.Literature Review on STEM Materials

Problem based learning is the other strategy recommended for STEM teaching. Because scholars argue that learners can only engage learning by exploring, inquiring, solving problems, thinking critically. As a result related to STEM, all efforts focus on strategiessuch as inquiry learning, project-based learning, constructivist learning, problem-based learning and technology integration into across all STEM disciplines (Asghar, Ellington, Rice, Johnson and Prime, 2012). In their study Asgar et all. (2012) reported that teachers confronted serious individual and institutional barriers while learning and employing the integrative STEM-Problem based modules in practice. They concluded that teachers, administraters, universities should realize that their roles should change from the transmitter of knowledge to that of a facilitator of knowledge, also administrators should support teachers and foster their professional development, should realize the barriers while implementing PBL approach and support the teachers, help them to be a part of STEM community and provide opportunities for interdisciplinary work and collobaration, universities should prepare pre-service teachers that can work with other teachers so mentoring and coaching systems should be used (Asgar et all. 2012). Problem based learning is included one of the great stem education elements with career, technology, and life skills (/blog.discoveryeducation.com/).

Zemelman, Daniels and Hyde (2005) list ten best practices for teaching math and science which provides insight into effective practices in STEM education especial for the integrated STEM education.

2.STEM Materials

2.1.Literature Review on STEM Materials

These are;

1. use manipulatives and hands-on learning
2. cooperative learning
3. discussion and inquiry
4. questioning and conjectures
5. use justification of thinking
6. writing for reflection and problem solving
7. use a problem solving approach
8. integrate technology
9. teacher as a facilitator
10. use assessment as a part of instruction.

Presenting students qualified STEM education requires an innovative curriculum, instruction and assessment. Science and maths curriculum should be integrated technology and engineering. All students must be a part of STEM vision and all teachers must be provided with the appropriate professional development opportunities that guide them acguiring STEM literacy.

Bybee (2013) clearly articulates that the overall purpose of STEM education is to further develop a STEM literate society. His definition of "STEM literacy" refers to an individual's:

·Knowledge, attitudes, and skills to identify questions and problems in life situations, explain the natural and designed world, and draw evidence-based conclusions about STEM-related issues.

·Understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry and design;

2.STEM Materials

2.1.Literature Review on STEM Materials

·Awareness of how STEM disciplines shape our material, intellectual, and cultural environments; and

·Willingness to engage in STEM-related issues and with the ideas of science, technology, engineering and mathematics as a constructive, concerned, and reflective citizen." (cited by Kennedy and Odell, 2014).

For engaging STEM education in the program Kennedy and Odel (2014) emphasized also promoting problem solving with engineering design process, encouraging inquiry based process, focusing on contextual learning via Project based leaarning, using and developing grade appropriate materials which are hansd-on, minds-on and fostering collaborative learning, developing students' meta-cognitive skills, providing students both formal and informal STEM learning experiences and presenting opportunities to be a part of a community of STEM and STEM workforce.

Roberts (2013) stated that STEM education provide chance for students and teachers to develop 21th century skills. However it is more than just maths and science . Technology and engineering are the other fundamentals. Also main goal in STEM education is to reach "innovation". For reaching innovation students should also be trained about creative problem solving techniques, teamwork and collaboration skills.

Besides all of them some techniques and methods also advised for STEM education like Predict, Observe, Explanation, 5E and T-SM-E method in the literature. Hudson, English, Dawes, King and Baker (2015) have carried out a study with 4th primary school students.

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They used ICT materials for making students and teachers to prepare STEM lessons One activity that sought to engage students in learning about the properties of materials was using a predict-observe-explain (POE) technique where students tested the properties of materials (e.g., aluminium, paper, polyfoam) to determine if they could be squashed, stretched, twisted or scratched. They also tested the materials to determine if they were waterproof, particularly for consideration of designing and making the medical kit design. Students were asked to predict what will happen by underlying “yes”, “unsure” or “no” and then observe the result by circling yes, unsure or no. The student was unsure if plastic would stretch but wrote it “easily stretches” after testing the plastic. Similarly, the student was unsure if polyfoam was waterproof but after testing was able to circle “no” and write “absorbs water”.

Also in some studies 5E model is emphasized in STEM education. The model was used for preparing lesson plans and curriculum in STEM education and it includes engagement, exploration, explanation,elaboration and evaluation phase (Ceylan and Özdilek, 2014).

In their study Saito, Gunji and Kumano (2015) stated that teachers have difficulty in integrating technology in STEM lessons ans especially Japanese teachers underlined that they grasp that they don’t provide enough chance for their students to get information about technology and understand it. Becuse of this they have developed T-SM-E method that has three phases. The first phase is technology phase in which teachers find technology that exists in our world interesting.

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At this phase the aim is to demonstrate students, technology is the result of engineering so teachers share interesting stories about technology, want students to define the limitation of that device or machine, define the factors affected the quality of the machine etc. Published materials like books, web sites of companies are used as materials. At the second phase teachers identify the related science and maths contents which foster students' thinking about the topic and generally here the published materials and web sites are used. In the third phase engineering, teachers guide students to find the engineering problem about or related the device/tool or the content and lead them to carry out engineering process. At these phase commercial product copies are generally used as materials. So because of these it can be recommended that in STEM studies the technological devices invented by scientists or role-models should also be focused.

Finding quality curriculum materials for integrated STEM education is currently a challenge for many teachers. Several online resources provide teachers a variety of STEM activities, but the quality varies (Guzey, Moore and Harwell, 2016). By reason of, many researchers emphasized that teachers should produce their materials according to their own needs as well.

In STEM education hands-on and experimental materials especially underlined. Because these kind of materials provides a strong motivation for learning and make the learning meaningful.

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It often requires numerous materials and resources for students to investigate solutions to real world problems through designing, expressing, testing, and revising their ideas. Materials can include construction tools such as saws, measuring devices, and hammers; electronic materials such as computers, design programs, robotics kits, and calculators; and other materials used in design, which could include wood, styrofoam, glue, cardboard, or construction paper. Through the use of these materials in design activities students can better understand technology. A broad definition of technology is anything that is human made that makes life easier (Stohlmann, Moore and Roehrig, 2012). By using these materials they desing “baloon powered car”,”mausetrap car”, “water rocket” and various “spaghetti bridges”(Cetin and Balta, 2017). Altan and Ercan (2016) investigated the effects of a Professional development program on teachers’ perceptions and competencies related to STEM education.

It lasted nine days and they use robotics, legos, electronical devices for desining things such as solar vehicle, GPS for deciding the coordinates, Maps etc. After the program teachers beliefs changed related to STEM disciplines and they stated that STEM education should improve creativity, problem solving, inquiry, technology-utilization skills. Teachers also presented suggestions for the curriculum adaptation on STEM and they also emphasized the improtance of engineering process and they felt adaquate about integrating STEM disciplines.

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In their study Campell and Jobling (2014) stated that it is important to use authentic problem based on a design technology or engineering need which can be solved by students for an integrative STEM education. Because students' interest increase in science when work on real life problems. So in their study they designed four different problems and students created four projects. One of them is HF-Autotrap which is used for catching householdfilies. While this is created waste materials. In second case the students created an aerated in vitor system for supproting plant growth. For aerating plants the students should invent the apparatus by themselves and again as a material they use glass, jam jars, culture tubes etc. In case three they designed a wind power generator system with low wind speed and low cost. While producing it they used scrap materials that are avaliable like alternator from a car. In case four they designed a water filter by using waste materials too.

Robotics can be handled an excellent tool not only of robotics itself, but of general topics in science, technology, engineering, and math (Stohlmann, Moore and Roehrig, 2012). In a study carried by iRobot, University of Massachusetts Lowell, and Massachusetts Technology Leadership Council's Robotics Cluster the teachers were introduced a set of Technologies that provide information about using robots to teach subjects in STEM curriculum, careers in robotics, and to build a community of teachers who use robotics in their classrooms. The researchers designed four hands-on sessions by using LEGO Mindstorms robot sets and workshops included short talks from founders and employees of local companies.

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For corporating the teachers with each other they incorporated short talks given by local teachers who are using robotics in their classroom and also included time for teachers to socialize with one another. The materials used in this workshop were designed to allow teachers and students to collect experimental data and then share it with other classrooms, both in their schools and through Internet (Stubbs and Yanco, 2009). Also Ayar (2015) reported in his study that robotics provide students with the opportunity to engage in hans-on activities and personal interactions, increase and sustain their interest towards engineering, foster their intrinsic motivation. In his study he worked with 145 students and students were presented computer programming course (6 hrs.), a basic electrical-electronics course (4 hrs.),a Proteus/PIC/MicroC training course (5 hrs.), and (d) electronics applications (printed circuit boards (PCB) and their production (4 hrs.). The summer program also included the speech of some professionals about their carrier process, how they became an engineer, what they had done so far and also includes field trips to some companies worked on engineering.

Kim, Kim, Yuan, Hill, Doshi and Thai (2015) also carried out a study on pre-service elemantary teachers. They presented a teacher prepation course to STEM by using robotics and they found that teachers STEM engagement were significantly improved. They used My Robot Time and RoboRobo robotics kits for the activities and they reported that robotic activities led to improvement in all fields;

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maths, science, physics, enginering and in total STEM knowledge, also develop abilities like spatial ability, interpreting graphs, Picture sequencing, creativity, problem solving, collaboration and communication. According to them, robotic activities also foster students' interest, motivation and direct them into STEM learning and careers. Kopcha, McGregor, Shin, Qian, Choi, Hill, Mativo and Choi (2017) carried out a research with 5th grades students and their teachers on integrative STEM education. They investigate the effect of robotics on students computational thinking. They stated that students and teachers find the robotic education which lasted nine days enjoyable but challenging. Also teachers stated that students collaborative problem solving skills developed and they stated that this process supports meaningful learning and transfer of learning. The students stated that they learned much, their self-efficacy and preserve in face of failure developed.

Engineering is the core of the STEM curriculum which includes "engineering process" and "design process" thus Engineering Technology faculty and high school science teachers should develop projects where students esign, built, test in a short time and experince real World examples. According to ASME Vision 2030 report where the needs analyzes and current weaknesses of graduates expressed by their employers as well as the early career engineers themselves are that Mechanical Engineering Technology (MET) programs should present curricula that leads innovation, creativity, and entrepreneurship as well as emphasising on practical applications of how devices are made and

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2.1.Literature Review on STEM Materials

work. The ASME Vision 2030 report states that: “To address these weaknesses, an increase in and enrichment of applied engineering design-build experience throughout degree programs is urged.” With all these needs, 3D printers and related softwares become very important which provides students to design, model, simulate and prototype. So the 3D printers such as Prusa Mendel Rep Rap, Delta Reprap, Trinity labs, Aleph Objects, Type A machines, Printrbot LC, Makerbot r-Replicator, Statasys Mojo are examined and recommended (Irwin, Pearce, Anzalone, Douglas and Oppliger, 2014).

In one study which investigates an effective integrated STEM education reported some recommedations from teachers on effective STEM education and main factors that affected the teachers implemantation of STEM. According to the results in terms of lesson planning teachers emphasizes focusing on connections, translations of representations, understand student misconceptions, understand student capabilities, problem solving based, student centered, build on previous knowledge, focus on big ideas, concepts or themes, integrate technology and real World and cultural relevancy. In terms of materials, technology resources, broad view of technology, material kits for activities are recommended (Stohlmann, Moore and Roehrig, 2012).

For authentic learning to take place, students need to be given opportunities to design processes or products. The materials kits have to be purchased each year as students use the materials in projects such as designing a dragster out of wood and building a Rube Goldberg machine.

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Electronic technology materials are also necessary for teachers to be the most effective. Internet websites, applets, design programs, dynamic software, robotics software, and calculators can all be integrated into lessons (Stohlmann, Moore and Roehrig , 2012) In Material kits; lego training kits, wooden kit sor simple machine kits can be included. Especially in integrated STEM education using LEGOTM material increased students' attitude towards STEM in a positive way when compared to traditional classrooms (Toma and Greca, 2017).

For STEM education inquiry based method is strongly emphasized that we have mentioned before. Science education goal should be to teach students the methods of scientific inquiry and engage students with real world problems as long-term projects. For reaching this goal, the strategy of using mashup that provide students with the ability to gather and analyze complex data sets such as Yahoo Pipes will be useful (Crippen and Archambault, 2015). "Common mashup services include maps (e.g., Google Map), videos (e.g., YouTube), socialnetworks and discussion tools (e.g., Facebook, Google Plus, and Edmodo), photos (e.g., Flickr), search (e.g., Google, Yahoo!), visualization (e.g., Many Eyes), and widgets (e.g., Widgetbox). These applications and sources offer numerous interesting new data outputs, including visualizations of multiple datasets. For example, one can use Google Maps and images from the Web to produce a representation illustrating the impact of rising sea water due to climate change on U.S. coastal cites (www.mibazaar.com/).

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Virtual platforms like Second Life is also recommended for STEM education. Second life is a free unline virtual platform in which user can imagine and create locations, objects abd activities. It is a free online virtual environment. In one study aproject called as “The Virtual Engineering Sciences Learning Lab” was carried out and it presented students an online interactive learning environment that introduces students to quantitative skills and concepts through visualization and interactive problem solving. The content mainly focuses on positional numbering systems, logic operations, gates, and flip-flops, and visualization of a rate flow problem from differential equations via Second life. As a result there was a meaningful improvement of students learning from workshops. In workshop three that the participants have least knowledge the biggest improvement was recorded and the average score increased from 27.46 percent on the pre-test to 69.67 percent on the post-test. Besides VESLL is found effective for the content delivery and students have a strong interest in VESLL as a learning tool. Its potential benefits are to provide students with imaginative, interactive ways to engage STEM content make projects like VESLL an important, arguably essential, area of exploration (August, Hammers, Murphy, Neyer, Gueye and Thames, 2016).

For attracting women into STEM disciplines, Math Options summer camp is organized that conducted three week long and accepted girls entering ninth and tenth grades. The camp focused on the use of technology called as an “integrated Jean project” which introduce campers to different areas of engineering (electrical, mechanical, and plastics)

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2.1.Literature Review on STEM Materials

in hands-on lab-based modules. The camp aimed to provide girls deeper investigation of STEM carreers before entering university. It is designed around the re-engineering of an existing product (a pair of blue jeans) to create a new product (a blue Jean bag) that was relevant to the girls. It provides girls to have a chance about experiencing multiple engineering processes and technology used to design and produce something from begining to end. At the workshop starts with imtroduction and teamwork. The teamwork is based on a challenge “Jungle escape game” th the campers were asked to imagine that they were stranded in the jungle after a plane crash. They used the K’NEX to create a helicopter to fly them out of the jungle. The students could see the black and White photo of the helicopter only one time but they couldn’t speak while they are creating it. They have 40 minutes. The students could not bring pieces with them or touch the model; they had to rely on their memories. When the helicopter was complete, a facilitator checked it for completeness. After that they design, model, simulate and they produce two bags one for themselves one for a charity board according to the criterias defined at the begining. The results of the assessments show that participants had positive experinces and learned many things about STEM fields (Dave, Blasko, Holliday-Darr, Kremer, Edwards, Ford, Lenhardt and Barbara Hido, 2010).

Videogames are also handled in the literature as one of the main soruces of learning STEM subjects. World of Warcraft, Food Force, Whyville are some of these games that the students learn science, math and engineering.

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According to studies, Rivercity an ecology game diminished the learning gap between D and B students and takes the D students to the point of B.Learning outcomes were found positive besides being well designed.

The reasons for games being successful;

- Games can be adapted to the pace of the used.
- Games appeals all kinds of senses simultaniously which catches all different learning styles .
- Games Works just-in-time principle that the learner can see the wrongs and writes immediately.
- Games are also particularly adept at dosing information delivery. Complex tasks are presented first as a small core experience that is practiced multiple times before being progressively extended into a longer, more complex sequence. The superior efficiency of this approach (known as concurrent chaining) has been compared with whole-task learning in.
- Games are also useful for acquiring the knowledge. They provide a rich environment of objects and activities which “situated the meaning”, that contextual elements support the information being conveyed.
- Games provides a social enviroment which can also reinforce content. Well-constructed social interactions around societal goals within the game will drive learner engagement and achievement.
- Content is reinforced through continuous, immediate feedback that players get points, levels, titles etc. Even with their tiniest successes. These rewars contribute to the self confidence.

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- Learner control over navigation through tasks and activities is a surprisingly important feature of effective learning games. The meta study by J. J. Vogel et al. found learner control/ autonomy to be one of the few easily identified predictors of enhanced learning outcomes whereas the study by R. M. Ryan et al. found that it was critical to enjoyment and motivation as well.
- Games also requires an active participation that the learners form hypothesis, make experiments and discover the results of actions that is very similiar to inquiry-based learning.
- Finally, with all else being equal, games invite more time on task. Teenagers commonly spend 5 to 8 hours per week playing games, and this equals or surpasses the time spent on homework each week. B. D. Coller's racing car game, designed to teach numerical methods, resulted in twice the time spent by students on homework as a traditional class, with greater depth of understanding of the relations between concepts, and an overwhelming demand for the follow-up course (Mayo, 2009).

Also a Project called as "STEM4youth" created a website which aims to produce a compherensive, multidisciplinary content and present informal education such as extra curriculum activities, science festivals, university lectures and open web accessible materials (Brzozowy, Holownicka, Bzdak, Tornese, Lupianez-Villanueva, Vovk, Torre, 2017) . The content organized around six disciplines; Mathematics, Physics, Astronomy, Chemistry, Engineering and Medicine.

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They use various strategies and tools for presenting scientific challanges in an attractive way such as learning by experiment, gamification, citizen science at schools. They also provide information about STEM occupations and their positions in Europe.They created a web site http://www.stem4youth.eu/ and shares all kind of materilas related to STEM subjects. Especially the website includes some card games and online games. Card games are; “(Precision) medicine I wish for” and crosswords. Online games are ;

- gold rush https://play.google.com/store/apps/details?id=cz.bukacek.goldrush,
- jeopardy https://www.youtube.com/watch?v=CshXIx2D5NA
- puzzles https://www.youtube.com/watch?v=j-2CmI5MkKI
- the triangle game https://www.youtube.com/watch?v=B5L0tzuZTqY
- soma Tic Tac Toe
- https://play.google.com/store/apps/details?id=cz.bukacek.soma_tictactoe, funny Pictures https://www.youtube.com/watch?v=AaQ2nTSf-D8.

All the details related to games can be found the link https://olcms.stem4youth.pl/content_item/detail/55

In their study Kintsakis and Rangoussi (2017) used Moodle for teaching 5th students Scratch in a game-based approach. The students asked to save the cat from the trap. In moodle students learn how to use scratch and in Scratch they can apply it. The students also produce their games on scratch. As a result students show positive attitude and engagement and they evaluated the experience pleasant and valuable.

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- jeopardy https://www.youtube.com/watch?v=CshXIx2D5NA
- puzzles https://www.youtube.com/watch?v=j-2CmI5MkKI
- the triangle game https://www.youtube.com/watch?v=B5L0tzuZTqY
- soma Tic Tac Toe
- https://play.google.com/store/apps/details?id=cz.bukacek.soma_tictactoe, funny Pictures https://www.youtube.com/watch?v=AaQ2nTSf-D8.

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So in STEM education using e-learning platforms and gamification foster students' motivation, engagement and interest.

AR games are also recommended for STEM education. Shapovaalov, Atamas, Vilyk, Shapovalov and Uchitel (2018) They designed a website called STEMUA for the systematization of STEM materials created by teachers. With STEMUA they proposed an informational management of AR materials and their goal is allowing the widespreas dissemination of the virtual education and AR materials.

In some studies; effective learning approaches for STEM reported as followsa.project-based learningb.inquiry based learning and c.digital game-based learning. In digital game based learning ,learners face to challenges through simulation or role-playing in the game. In the past there were some e-learning platforms such as LMS or MOOC, but 3D virtual wolds like Second Life, Open Sim Etc. are the alternative and effective options that engage students and foster their motivation (Pellas and Kazanidis, 2014). Today with the advances, web based Technologies combine 3D multi users virtual worlds like Soodle or Scratch for Second Life (Pellas, Kazanidis, Konstantinou and Georgiou, 2016).

2.2.STEM Materials in Turkey

The materials searched used in STEM via different channels such as articles, thesis and web sites. Firstly the materials used in Turkey is investigated. While the research is been carried out the keywords
" STEM" and its Turkish version "FeTeMM" were used between the dates 10.01.2020-10.05.2020. The thesis were reached from the Turkish Higher Education Institute Thesis Database "YOK Tez Tarama Merkezi" and articles were reached from "Türkish Science and Technology Institution Database" (Tübitak Ulakbim).

At this report "document analysis" was used as a method. Document analysis is a systematic procedure for reviewing or evaluating documents—both printed and electronic (computer-based and Internet-transmitted) material. Like other analytical methods in qualitative research, document analysis requires that data be examined and interpreted in order to elicit meaning, gain understanding, and develop empirical knowledge (Corbin&Strauss,2008;see also Rapley,2007). Document analysis is often used in combination with other qualitative research methods as a means of triangulation—'the combination of methodologies in the study of the same phenomenon' (Denzin, 1970; cited by Bowen, 2009). Document Analysis as a Qualitative Research Method.

While the researches were included at the report, the criterias below were used;

• Usage of the words "STEM or FeTeMM" in the title of the study.

• Whether the study was carried out in the field of education

• Whether the study carried out in Turkey

2.2.STEM Materials in Turkey

Whether there is a STEM application/experiment has been done in the study and the materials used in the applications have been included.

• Whether the study is published as a thesis in the YOK database or as an article in Tubitak Ulakbilim database

• Whether the study has open access and full text

While these criterias were decided, it is mainly focused on the doctoral theisis which are accepted more academic. Doctoral thesis are written by the experts and the articles are evaluated by the magazine's refrees so there is a mechanism that controls them. But this is not the case for the master thesis in general.

For the report, when the studies that used the words 'STEM' or ' FeTeMM ' in their title and published in the field of education were filtered, 68 studies were reached. Eight of these studies were not open access or had no full text. 60 articles are examined. From these articles;

2 of them weren't carried out in Turkey.

Although there were 7 more practices/experiment studies, no information were presented about the the practices/experiments or no information were presented about the materials. So they were all omitted.

34 of them were not based on practices/experiments on STEM (In these studies, one of the sudy is one of them is a theoretical article, one of them is a scale adaptation, 6 of them are literature reviews and in other studies teachers, academics, students or differents stakeholders' views are examined. Current practices for STEM were evaluated in Turkey, teachers' experiences were examined by using phenomenologic method etc).

2.2.STEM Materials in Turkey

From doctoral thesis, 30 of them is examined. 2 of them is not open to public, 10 of them don't include practices/experiments so 18 of them found appropriate and included in our study. We also included two master thesis which have the criterias of our study and in total we examined 35 studies. According to the results;

We categorized the materials used in these studies as

1.Simple Materials: Materials that are often used as auxiliary, easy to find, and easy accessible. For example: pen, paper, ruler, cardboard, scissors, pipette, paint, bottle, silicone, simple electrical circuit elements, laboratory supplies, food, recycling materials.

2.Technological Materials: The materials which are supported technologically. For example: arduino, raspberry pi, sensors, 3D printer, filament, computer, robot kits.

3.Published Materials: Graphics, chart visuals, lesson plans etc.

4.Training Kits: Kits made of various materials like wooden, lego, plastic etc. without coding and software and non-printed play sets.

5.Computer Programs: They are handled under two headings;

a. Software and coding programs: Include programs with coding. For example: Mblock,, Scratch program, Lego Education EV3 program

b. Other programs: Programs that do not require coding (Simulations, animations, video and audio editing programs, drawing programs) For example: Tinkercad, Google Sketchup (3D modeling program), Movie Maker (video editing program), Algodoo, Powtoon (animation and video production program).

2.2.STEM Materials in Turkey

6.Games; that are handled under two headings. Online or other games (published, game kits etc).

In seven studies, computer programs are used only. They are;

·Softwares and coding programs and

·Other programs which include animations, videos etc.

Scratch, code org. , Ardunio Uno and Lego Education EV3 softwares and programs were used as softwares and coding programs. As other programs the programs which didn't necessiate coding like; Google Sketchup, Algodoo, Phet and Powtoon were used.

In 16 studies simple materials were used such as; straws, ties, duct tapes, adhesives, scissors, utility blades, wooden plates, toothpicks, marhsmellows etc. Especially recycling materials were used according to the topic and design that the project aimed.

In seven of the studies robotic sets were used with softwares, simple materials, training sets etc. The robotic sets which were used Mbot robotic kits, Lego Mindstorm Ev3, Lego Wedo and Mblock program, ardunio Uno as a softwares.

In other five studies simple materials described below used with computer programs; training sets, technological materials. Computer programs include like Audacity, moviemaker, powerdirector and geogebra which is a geometry software. Training sets includes Tom Tech Wooden, K'nex, Leogo Duplo . Technological materials include WeDo 2.0, Albert School,Play 600, Makey makey,little bits, makedo,microbit.No games have used in STEM studies so far in Turkey nor online neither the other kinds.

2.2.STEM Materials in Turkey

Besides scientific documents websites also searched and the materials examined presented by the websites. Various training sets which can be identified as commercial construction materials were reached. These sets are the ones which are avaliable for building materials and which includes building challenges. Seven kinds of materials were presented in this context. These are wooden training sets; Tomtect 190, EVO STEM Training set .Electronic training sets; Earthquake alarm device, Hydraulic Robot Arm Model, Human Arm Muscle Model, Stud Circuits Exceptional 750 Experiments, Fischer Technik Optics and Lights STEM Set, Makey Stem Electronic Kit, Robotic Kit Stem Electronic Set, Elektrolab Midi Electrical Experiments Set, 698 Circuit Cubelets, LittleBits Class Set, Canoe Lego training sets; Controlled Motorized Model Lego (4 Models), 170 Pieces and K'nex Mechanical training sets; Balloon Power Outgoing Car, Mechanic Belt Vehicle Making Set, Fischer Technik Mechanical Systems Mechanical STEM Set, Gravitrax Catapult Ravensburger Skill Game, Gravitrax Magnetic Launcher Ravensburger Skill Game, Da Vinci Hammer Stemist Box Stem Set, Da Vinci CatapultStemist Box Stem Set, STEM Simple Machines Activity Set, Compound Simple Machine Let's Experiment Set, Let's Make Excavator Experiment Set, Hover Disk, Kaleidoscope, Air Science, Clean Water Science, Environmental Battery, Magic Magnets Robotic sets: Sphero, Lego Mindstorm EV 3, Ozobot, LightUp Edison, 4M Maglev Train 4M Solar Airplane,Insectoid, Wind Generator, Weather Station, Two Axis Drawing Kit, Raspberry Pi GrovePi Starter Kit, Arduino Maker Kit, BBC micro:bit and Makey Makey

Softwares; Hour of Code, MIP App Invertor and Tinkercad.

2.3. STEM Materials in Europe

By using the key words “materials used in STEM education”the Google finds 2.880.000 results. By looking at the citiations, it is decided to examine ten pages of Google that means “100 documents”. From these documents, mainly the articles are focused on but if it is found related the topic and original some proceedings were also included in the study. According to this; from these 100 documents; seven of them books and three of them proceedings so except one proceeding which was related to our topic all 9 documents were ommitted. From 91 documents 24 documents; 23 articles and one proceeding were examined. 67 of the documents which some of them were literature review, some of them were about the attitudes or perceptions so they were also examined but not included in our categorization.

The results are presented below that;

From these studies;

In five of them computer programs and softwares were used such as Youtube videos PowerPoints, moodle, Second LifeTM, Scratch, Proteus/PIC/MicroC, CAD softwares

In five of them only simple and recycling materials were used such as dirty socks, butter, fruit juice,bottkers, chopsticks, baloons, cd etc.

In four of them robotic kits were used with softwares such as; iRobot Roomba ,Create Gumstix Robostix Wifistix 4-pin serial conn., Roo232 + cable Battery pack, LEGO Mindstorms, My Robot Time and RoboRobo robotics kits.

In eight of them, simple materials were used with technological devices such as tape recorders, motors, batteries, circuits etc.

2.3. STEM Materials in Europe

Also with published materials like worksheets.

And In one of the study training kits; lego toys were used. In one study simple materials, training sets, technological materials, softwares nearly all kinds of materials were used.

As it is seen below no games are used in the studies and generally technological materials, robotic kits and softwares are preferred in STEM education and technology is the first topic focused on STEM education. Although for attracting students and gaining them a positive attitude there should be some other type materials from different sides of the content; for example games and role models.

If the materials widely used categorized in STEM education;

1.Simple Materials: All kinds of accessible materials

- Recycling materials
- Craft sticks, glue, paper and plastic cups and plates, pipe cleaners, PlayDoh, aluminum foil, ping pong balls, and cotton balls.

2.Technological Materials :The materials which are supported technologically.

- *3D Printers; although it is not reported as a main requirement, especially for the later stages it is advised for STEM labs. 3D printers foster design skills amd add a deeper dimension to STEM porjects.Students draw, design and model by using 3D printers.*
- *RaspberryPi: The Raspberry Pi is a low cost, credit-card sized computer developed for computer*

2.3. STEM Materials in Europe

science education. It plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It enables people to learn how to program in languages like Scratch and Python.

- LEDs: Light Emitting Diodes are a staple in most makerspaces. These used for experiments, to make projects look and function better and are just fun to play with.
- Copper Foil Tape: This tape is made of thin pure copper so its extremely flexible and can take on nearly any shape. You can solder to it, and the tape can carry current like a wire. Copper tape is great for making paper circuits and with use of circuit stickers.
- littleBits: Color coded electronic building blocks that connect together with magnets and allow for the creation of inventions while engaging in powerful hands-on learning in STEM/STEAM. There are many different bits or modules that allow for experiments.
- Chibitronics: These are LED circuits on peel-and-stick stickers. Build circuits without soldering, plugging wires, or clips. Instead, use the stickers with conductive tapes to draw circuits on paper and other crafts. Learn to build circuits while make interactive artworks
- Squishy Circuits: These allow kids to create circuits & explore electronics using playdoh. You build a conductive & insulating dough and then assemble for a squishy circuit.
- Snap Circuits: Teaches basic electricity, circuits and electronics. Use the provided manual to build projects such as FM radios, digital voice recorders, AM radios, burglar alarms, doorbells, and more. All parts are mounted on plastic modules and snap together, no soldering

2.3. STEM Materials in Europe

- required.
- Robotic Kits

Lego Mindstorm Ev3, arduino, raspberry pi

VEX Robotics: It is an educational robotics for all levels. It provides students science and enginering principles besides creativity, teamwork, leadership and problem solving.

- STEM Robotics&Pro:It is a robotic set for late primary and secondary schools students of ages 8-15. It allows to build 34 STEM models. It also includes pro controller, RJ cables etc.
- Specdrums, the rings that connect through Bluetooth to iPhone or iPad and allow students to create music without any instruments! The rings have a color sensor on the bottom, so when it detects a color, your device plays a corresponding sound.
- Sphero SPRK+ : It is a little robot is durable and waterproof with an added bonus of a transparent cover that flashes various colors. It also includes an app that offers a range of activities, we have incorporated SPRK challenges in elementary through high school classrooms. Students are introduced to programming with a draw and drive option, followed by challenges to teach drag and drop block coding, and advanced users can write their own JavaScript to program the robot!
- Coding Mat; The Sphero Coding Mat is an accessory for Sphero robots that includes different challenges to program to robot through the mat. The mat comes with activity cards that are customized for each side and lead students through different coding

2.3. STEM Materials in Europe

challenges.

- Dash Robot: For elementary aged kids, the Wonder Workshop Dash robot makes learning to code fun by presenting challenges and puzzles kids can solve. It responds to voice commands and can even sing!
- Cubelets Robot Blocks: It is for beginners, cubelets allow for students to design their own robot by snapping cubes with different abilities together and seeing what behavior happens. With adapters, Cubelets even connect to other building brick materials like LEGOs.
- Bee-Bot: For the youngest of robot programmers (PreK-First Grade), this little robot can be programmed to move by pressing the arrows on its back. The primary goal of the Bee-Bot is to introduce basic programming and a foundational understanding of how a robot responds to sequential commands. Outside of coding, students can also learn simple addition and subtraction, review sight words, and write simple sentences.
- Sphero: App-enabled robotic ball that can be programmed or hacked. It is designed to inspire a love of robotics, coding and STEM all through connected play.
- Root, is the newest robot in STEM Education. The robot is magnetic, so it can be programmed to travel over a white board and draw with an expo marker. Block programming is also included in the app as well.
- Dot & Dash: Dash and Dot guide kids through the world of coding and robotics, turning ideas into adventures. Works with Apple and

2.3. STEM Materials in Europe

- Android devices and runs on special apps that are packed with hundreds of puzzles that encourage learning through play.

*3.Published Materials:*Graphics, chart visuals, lesson plans etc.

4.Training Kits:

- Brainflakes are plastic snowflake disks have endless possibilities. Shaped like a snowflake, students join with other pieces in eight different areas. By using them tehy design and test.
- Legos; are classic building block has sparked imaginations for years. Most of the students will be familiar with them. They’re a bit smaller in size, so they should be chosen according to our students age.
- Connecting cubes; These classroom staples BEG to be played with! Their larger size makes them perfect for building taller structures, and fun colors allow them to be used in so many ways!
- Pattern blocks; they are usually so easy to find. Most math curriculum of years past included these in their packs. Use these for when students are working to build flat shapes, animals, and people. Pattern blocks do not connect together, so it makes them a little challenging to use in structure building.
- Gears and links, by tieing them, students can create simple machines.
- Magnetic tiles; simple flat shapes with magnets on each side. These little tiles quickly became the must use manipulative at the lab. The students can build tall buildings, shapes, and rockets with magnetic tiles.

2.3. STEM Materials in Europe

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- IQ Builder: which assist in demonstrating children maths, science concepts by having them cahnce to cunstruct and engage in engineering.
- Lego Gadgets: Students can build 11 different machines wşth it and enhance students’ creativity.

2.3. STEM Materials in Europe

- K'nex Education Set: Allows kids to desşgn real wold machines with its 221 parts.Students also use it as a team and provides teachers to carry out inquiry based teaching process.
- GoldieBlox: Construction toys for girls that promote STEM education and encourage more females to try engineering as a career choice. Founded by Debbie Sterling who herself graduated with a degree in mechanical engineering. Started because there were not enough STEM toys for girls.
- Tomtect 190: A wooden set includes 500 parts, by using it students can structure a variety of things.
- EVO STEM Training set: It is a wooden set taht students design more that 30 things that Works with motors, knetic energy etc.
- 5 Set STEM Kit, STEM master etc.

5.Computer Programs

- *Scratch*
- *Code.org*
- *Tinkercad: it is an 3D modeling program, but that's not what all it does. Tinkercad allows usto create 3D models and automate modeling through block coding.*
- *Makey-Makey: These inexpensive little circuit boards combine coding, invention, creativity, and electronics. It is used by plugging them into a USB .port of a computer or Chromebook (no software required), and youit can be turned any conductive item into a keyboard. You can play a banana like a piano or Pacman with PlayDoh buttons! It can be a tool used for all grades, advanced students can program their own games*

2.3. STEM Materials in Europe

using Scratch and solve more complex design challenges.

- Quiver App, it is a Print out a coloring page from Quivervision.com, and by coloring them using the app to watch the drawing come to life through augmented reality.
- OSMO Coding: Also a great item to have for centers or other independent learning times, the OSMO coding game teaches basic block programming by having kids physically build the code. Using the included coding command blocks and an iPad, kids solve problems and have adventures while learning the basics of programming.
- Makeblock: Open-source Arduino robot building platform. Multiple kits available that range from a starter robot kit, drawbot, robot gripper and the mBot. This is an all-in-one solution for kids to enjoy the hands-on experience about programming, electronics, and robotics.
- Merge Cube : It gets augmented reality into our hands. By downloading one of the Merge Cube apps on iPhone or iPad and scanning the cube, we can dive into a new world on each side of the cube.
- Google Sketchup, Movie Maker, Algodoo, Powtoon etc.

6.Games:

When the articles or academic studies taken into consideration, no games used at studies. But on the web; it can be reached STEM games such as;

2.3. STEM Materials in Europe

- Minecraft: This virtual game where you dig (mine) and build (craft) different kinds of 3D blocks within a large world of varying terrains and habitats to explore. There is a game MOD called MinecraftEDU which is tailored for use in schools. Learn more about it here
- Mystery Math Town: A web based game which teaches math to secondary school students. The mission is helping the ghost for rescuing the fireflies from a hiddeb Mystery Math Town. https://tryengineering.org/games/
- Cyberchase
- Brainpop STEM
- How to be an inventor etc.
- https://ssec.si.edu/stemvisions-blog/educational-stem-games-students

As board games;

- Science explosion
- Professor Noggin's Wonders of Science
- Dr. Microbe etc.https://techiehomeschoolmom.com/educational-games-for-kids-stem/

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3.Role Models in STEM Education

3.1. Reasons for Women not to Choose STEM Fields and Its Results

In general women are more successful in many educational outcomes such as college access and persistence but they remain less in science-related fields (Bettinger and Long, 2005). Over the last three decades the number of women has decreased in STEM fields and no one has a certain answer about the reasons. But evidence shows that self selection of girls away from STEM fields start at an early age (Milam, 2012). The reasons of losing women in STEM fields are;

- Social and cultural influences that the girls are influenced by the expectations of society and gender stereotypes. Girls may learn that science and technology are more appropriate for boys socially.
- Lack of opportunities for girls like materials, activities and feedback; non stimulating learning environments (Jansen and Joukes, 2012).
- Lack of self-efficacy which is the greatest predictor of success (self efficacy affected by mastery experience, vicarious experience, social persuasions, and physiological or affective states... teaching structures, course placement, and self-regulated learning)
- Workplace culture that supports men
- Perception of women that lack of work-life balance in STEM fields
- Sector failure about leading, training and recruiting women in STEM fields
- Inhospitable culture of IT industries
- Lack of role models (Milam, 2012).

In particular, the presence of mentors, role models and social support for learning is associated with positive learning outcomes for girls. In fact, role models may be even more important for girls than

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3.1. Reasons for Women not to Choose STEM Fields and Its Results

for boys (Milam, 2012). For women generally one of the main reasons is lack of role models that support their motivation. When compared to men, women are more likely to drop out of STEM majors (Herrmann, Adelman, Bodford, Graudejus, Okun, and Kwan, 2016). This is a case that not only affects the women but also affects all the sectors (Milgram, 2011). It may have very serious results like a male-dominated economy, shortages in critical fields (Bettinger and Long, 2005). Women bring a different perspective that shapes and influences STEM disciplines. The more women in STEM, the better society will be, because the society benefits the women's experience. Diversity helps groupthink and results new perspectives and solutions that women solve the problem differently. It is also benefit for women that they can enter jobs easier in STEM fields and earn %33 more than women who aren't working in STEM fields (Milam, 2012).

We are all enriched when women fully contribute to the advancement of science and technology. It is important for women and girls to see female role models in workplaces so that they can get the message that women can work and still have a personal life. Generally women get messages from society about STEM fields "that career is not for you" and educators should correct and change this message as "Yes, you can and this career is for you'. (Milgram, 2011). So developing toolkits or materials special to women/girls can engage them into STEM fields.al., (Adelman, Herrmann, Bodford, Graudejus,. Okun and Kwan, 2016).

Role models are effective tools for women retention in STEM fields. Female role models support women and prevent the harmful effects of

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3.1. Reasons for Women not to Choose STEM Fields and Its Results

negative stereotypes. For example, women who had a math test got better results when they encountered a female role model who was portrayed as highly competent in math compared to male models (Marx and Roman, 2002). Also taking the math course from a female professor enhanced womens' math self concept and implicit attitudes toward math (Stout, Dasgupta, Hunsinger and McManus, 2011). Also women who read about a female successful graduate of their university in the same field perceived themselves more successful when compared to male role models (Lockwood, 2006).

Increasing the numbers of women in STEM involves two difficulties; one is retention of women in STEM fields and the other one is recruitment of women who are already working in STEM fields. Generally studies underlined the increasing the number and presentation of female role models but while female role models are effective in retention of women in STEM, for recruitment female and male role models can be both effective (Drury, Siy and Cheryan, 2011). For recruiting women into STEM fields generally female role-models presented.

3.Role Models in STEM Education

3.2. Role Models for Leading Women into STEM Fields

Women can be led to STEM fields with some special interventions especially by using role-models. Role models are important to motivate women because role models demonstrate their particular goals, the ways and convey the message if you follow these ways so you can succeed (Collins, 1996; Lockwood and Kunda, 1997). Also role models reduce the stereotype threat so develop the performance. Exposuring male models decreases the women's interest, belonging and perceived success. On the other hand exposure to female role models increases women's self concept and positive attitudes in STEM fields. A relevant role model helps students to attain identities and perceive a strong connection with the future. So recent studies put forward that thinking about the future and feeling connected to someone’s experiences plays an important role in college academic achievement (Adelman, Herrmann, Bodford, Barbour, Graudejus, Okun and Kwan, 2016). For example, the U.S government carried out a campaign called “Rosie the Riveter” which presents a female factory worker as a woman which is perceived as a man's job. By means of that campaign between 1940 and 1944 the number of women increased by %57 to 20 million though not all of these women work in factories. With this campaign women get the message “nothing is strange at working for a men job.”

Another successful campaign is carried out by IWITTS called CalWomenTech which provides two year colleges recruitment strategies and training. With this Project San Francisco's Computer Networking and Information Technology (CNIT) program reached its highest percentage of female students, from a baseline of 18.1% to 30.1% (an increase of 12 %).

3.Role Models in STEM Education

3.2. Role Models for Leading Women into STEM Fields

In 2000 American Association of University Women's study "Tech-Savvy" educated the girls about computer fields and they reported that girls were reluctant for computer careers because they thought that they should work all the time, with no time for personal lives or families. For that reason it is important to present biographies of female role models that emphasize not only the ways and strategies they used for reaching their chosen careers, but also the joy they found in their work, as well as their personal interests and family stories. WITTS website www.iwitts.orgas includes these kinds of biographies and career videos featuring female role models in the IWITTS store (Milgram, 2011). Many young women don't want to sacrifice their personal life for their career. They need to get messages "yes you can balance your life and while working you can also live, you can balance both" (Milgram, 2011) .

MIT's women initiative, they make presentations to high school students like in web sites that tell about female scientists and engineers' careers like in National Academy of Engineering's (www.engineergirl.org) and companies run some studies like Microsoft's DigiGirlz. However empirical data report that in recruiting both male and female models are effective equally (Canes and Rosen, 1995; Price, 2010). Why are female role models more effective in retention but not in recruitment? Because the psychological threats are different in recruitment from retention. Women who have yet engaged in STEM fields don't have negative stereotypes about women's abilities so female role models can be more effective. Because for young women feelings of belonging is a stronger

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3.2. Role Models for Leading Women into STEM Fields

predictor than the other factors. Current stereotypes are more important than role models so for the recruitment of women in STEM fields changing the current stereotypes will be more beneficial (Drury, Siy and Cheryan, 2011). Another study that supported this idea that female or male interacting with a member of the field can motivate students and help them to believe in their potential (Cheryan, Siy, Vichayapai, Drury and Kim, 2011). Not the role models gender but the stereotypes presented by media, advertisements, websites etc. prevent the women selection of STEM fields. By the way, in their study Cheryan et al. (2011) found that role model interventions are effective if your role model is appropriate to stereotypes (Cheryan, Siy, Vichayapai, Drury and Kim, 2011).

There is also another Project using role models for STEM education that matches college students who are the twitter users with LinkedIn STEM Professional using an algorithm based on the similarity of their demographics and interests. The aim is inspiring students into STEM fields as well as to connect college students with role models. The algorithm ranks the top-5 STEM role models for each college student according to the similarities and it is up to student and role models if they want to connect by using Lınkedin or other ways.(He, Murphy, and Luo, 2016).

In some studies some interventions like attribution intervention and belonging information also performed. In their study Adelman et al. (2016) carried out an intervention that was based on four themes.

3.Role Models in STEM Education

3.2. Role Models for Leading Women into STEM Fields

One of the themes are attribution, belonging, overcoming adversity and normalized challenges. According to the study for attribution theme; role models emphasized sometimes they studied hard but they don't become successful, in belonging theme they emphasized although we spent money to go to classes and spend time for studying, it is normal not to get good grades everytime and the college is valuable that it is an investment for the future. The role models also underlined in overcoming adversity the rodel models served how to struggle with difficulties and normalizing challenges by underlying that every person who is in college has the same kind of experiences. As a result after the intervention the participants earned approximately two thirds of a standard deviation higher grade than participants in the control group (Adelman, Herrmann, Bodford, Graudejus, Okun and Kwan, 2016).

VHTO in the Netherlands organized activities with role models such as role speed date, guest lectures, work shadowing, mentoring. Also they organize teacher training programs for increasing gender awareness among science teachers and break stereotypes, gender inclusive science teaching and career guidance. Teachers also trained about how to help girls to have a positive image about STEM fields and how the girls learn about these topics. To support this aim VHTO developed a website with images and stories of male and female STEM professionals that the teachers can also use for helping their students have a broader and more diverse view on STEM. The website can be found www.ditdoeik.nl. VHTO also organized a programme called "sprint"for female students in higher education which has five themes;

3.Role Models in STEM Education

3.2. Role Models for Leading Women into STEM Fields

1.Institutional policy

2.Outreach to female students

3.Educational innovation

4. Orientation on professions and Professional practice

5.Regional networks. As a result of all their studies between 2004-2011 the percentage of students enrolled in a science subject increased dramatically. Moreover universities and secondary schools reported a high level of gender awareness (Jansen and Joukes, 2012).

Mentoring opportunities are also emphasized that female students can avoid choosing male-dominated fields due to biases against women and in some studies it is found that female doctoral students who have female mentors were more likely to succeed. In their study Bettinger and Long (2005) reported that in four year colleges in Ohio %5 5 of students taking English classes were female, physics, mathematics, computer science, and business, between % 44 to % 51 were females. But till now only % 14 were computer science and in engineering %16 so women were underrepresented. Less than one third of all faculty teaching introductory courses were female. Female representation among full time faculty was even smaller. So it is important to increase female representation by increasing the number of feaümale professors as role models by policy makers. There are researches that support this idea showing the gender effect encouraging women students (Rask and Bailey, 2002; Ashworth and Evans, 2001). According to Bettinger and Long (2005) study results female faculty members increase student interest especially in mathematics and statistics, geology,

3.2. Role Models for Leading Women into STEM Fields

sociology and journalism while in other fields such as engineering, physics and computer science the female faculty members don't have significant effect. For this result they demonstrate the small numbers of women in these disciplines.

There are some tv shows like SciGirlsthat aim to attract female students into STEM fields. A group of girls design STEM projects related to real life each week and mentors guide them. In the US there is also a Project called " National Girls Collaborative Project" a program/website that includes all the information about STEM activities in all US (Weber, 2011).

Also carrying out recruitment strategies like making presentations to counseling departments, distributing students posters and flyers of women in the sector, opening workshops for high school students or summer camps on STEM careers and fields, developing outreach materials that feature female role models; videos, posters, flyers, biographies etc. and distributing them to women in STEM career events after school STEM programs like SMART (Milgram, 2011), like Engineer Your Life (www.engineeryourlife.org/)or Girls' Nights Out project of California university (Weber, 2011) which present secondary school students hands on activities on STEM fields, mentoring opportunities (Bettinger and Long, 2005) are other effective strategies.

As it is seen below there are many ways and strategies for engaging women into STEM fields. But the important thing is transferring this learning and teaching process like presenting information, hands on experience repetition and practice for attracting girls into STEM fields and for recruiting them.

3.Role Models in STEM Education

3.2. Role Models for Leading Women into STEM Fields

If it can be done so we can succeed (Milgram, 2011). Research shows that, as a group, women care most about how STEM will be used to make a difference in the world, such as using engineering to make prostheses, while men are often fascinated with the technology itself, such as how big a hard drive is and how fast a processor works (Extraordinary Women Engineers Project,2005). These differences have implications for outreach materials and strategies. The best way to attract girls to STEM classes is to emphasize how the program helps others, and also focus on teamwork and collaboration, another area that research shows is appealing to women ” (Milgram, 2011).

3.3. Criterias for Role Models

While choosing role models there are some points that should be taken into consideration. These are;

- A sense of perceived similarity to the role model: If students perceive the role models' life, actions, thoughts etc. similar to themselves, they behave positively to that career, feel self-efficacy and demonstrate success. This similarity is not an objective one but a perceived one also this type of similarity. So to increase the effectiveness the role models should be chosen who are highly similar to students with their attitudes, values etc. Also it may be useful to concentrate on role models' efforts (Drury, Siy and Cheryan, 2011). According to social learning theory, psychological studies and empirical research suggest that students prefer to have role models whose race and gender are the same as their own as well as who share similar demographics and interests (He, Murphy, and Luo, 2016).
- Role models and learning opportunities should focus to create access as well as build confidence in females to pursue their interests in STEM careers (Weber, 2011).
- The role models must be perceived as competent (Marx and Ko, 2012; Marx, Monroe, Cole and Gilbert, 2013)
- Individuals must realize the success and the actions of role models in the mutual area of interest and direct contact with a role model is not necessary (Marx and Roman, 2002).

Individuals should be asked to think about their current academic situation and evaluate their relations or conversations with the role-models in this way.

3.Role Models in STEM Education

3.3. Criterias for Role Models

Table 1. Stereotypical and Non Stereotypical Items

	Stereotypical	**Non Stereotypical**
Clothing	Glasses, a t-shirt that read ‘‘I code therefore I am,’’ unfashionable pants, socks and sandals	Solid-colored shirt (v-neck t-shirt for women, polo for men), jeans, flip-flops
Hobbies	Playing video games, watching anime, and programming	Playing sports, hanging out with friends, and listening to music
Favorite movie Favorite television show	Star Wars Mystery Science Theater 3000	American Beauty The Office
Favorite magazine	Electronic Gaming Monthly	Rolling Stone

Cited by: Cheryan et al (2011)

3.4. Ready-Made Outreach Materials Featuring Female Role Models

For schools that would prefer not to develop outreach materials from scratch, consider using some of these off-the-shelf solutions to recruit more female students.

• Engineering role model videos: An excellent gallery of female role model videos that can be used recruitment purposes: www.engineeryourlife.org

• Career videos in 35 occupations: IWITTS has 35 career videos featuring female role models in a wide range of industries ranging from video game development to auto technology to robotics: www.iwitts.org/store/recruitment-products/career-videos

• Role model posters and banners: Featuring inspirational female role models on the job in industries ranging from manufacturing to welding to engineering: www.iwitts.org/store/

• Women in Technology Outreach Kit: Includes a series of customizable templates that guide you in developing recruitment materials for your school: www.iwitts.org/store/recruitment-products/ outreach-kit. (Milgram, 2011).

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Part 4. Gamification in STEM Education

4.1. Overview on Gamification in STEM Education

Defined as “the use of game design elements in non-game contexts” (Deterding, Dixon, Khaled, & Nacke, 2011, p.9), gamification has attracted the attention of many educators all around the world in recent years. Gamification in education can be said to be a set of activities used for solving education-related problems with the help of game mechanics. The purpose of using gamification is to create a real-world atmosphere to facilitate the learning process (Kim, Song, Lockee, Burton, 2018). The reason why gamification is claimed to facilitate the learning process is that it has several positive reflections on students’ motivation, engagement and learning achievement. Therefore, educators have been trying to make use of gamification in their classes to increase the efficacy of their teaching.

Gamification has a potential to increase students’ motivation. Many educators complain about motivational problems in their classes and gamification can be used as a tool to foster students’ motivation, active participation, and engagement in the learning environment (Domínguez et al., 2013; Su & Cheng, 2015). In addition to motivation, it also has positive reflections on learning achievement (Şahin, 2018), higher-order thinking skills (Pakman, 2018), and attitudes towards the course (Karagöz, 2016). In a gamified learning environment, students are more willing to participate in activities, are cognitively more active, can focus more easily and can adapt to challenging tasks (Çeker & Özdamlı, 2017).

Part 4. Gamification in STEM Education

4.2. Integration of Gamification in STEM Education

Used as an innovative tool to foster students' critical thinking, problem solving, creativity and collaborative studying, STEM education provides opportunities for students to experience knowledge-based real-life problems, which are requisites of 21st century's knowledge society (Çorlu, 2017). Studying in STEM-related fields help students become active contributors to society and technology-driven world (Bourazeri, AMab, Heidmann, Coelho, & Morini, 2017). Matched with today's technology-driven world, when today's classes and the traits of today's students are taken into consideration, it is inferred that their characteristics, expectations, and the environment that surrounds them are distinctive (Yurtseven & Karadeniz, 2020), which signals the need for making the instruction individualized or at least make the students feel belonged to the learning environment (Kaplan-Sayı, 2020). In this framework, gamification of STEM education can be considered as a good alternative to fulfill the requirements of STEM education and enrich the learning setting to address diverse student needs and backgrounds.

Gamification of STEM is pedagogically based on an active learning approach. Students work with different tools and resources to solve problems in problem-based learning context STEM activities that are initially conducted in the framework of a knowledge-based real life problem (Asığığan, 2019). When gamifying STEM activities, it is important that educators use the interactive aspects to attract students' attention and provide constant interaction and feedback throughout the activity. However, the focus of gamified STEM activities should not only be the game and it is crucial that students do not lose the focus of learning objectives. While they are having fun with the help of game mechanisms and elements, they should also reach the learning objectives without losing sight (Pirker & Gütl, 2015).

Part 4. Gamification in STEM Education

4.2. Integration of Gamification in STEM Education

As part of gamification, a combination of points, badges, and leaderboards are frequently used in STEM education (Ortiz, Chiluiza, & Valcke, 2016). In addition, targets and clear goals, instant feedback and optimal level of challenge are among the most important gamification mechanisms to increase students' engagement and motivation in STEM education (Lynch, et al., 2018). A meta-analysis conducted by Asığığan (2019) draws attention to the elements of gamification in STEM unit plans in general. Among the elements, the most frequently used ones were time challenge, points as part feedback, and materials as part of setting. In addition to this, narration, competition, game characters, targets, and game rules were integrated into STEM activities such as solid pressure, establishing an equation, force and motion, mirrors, patterns, electrical resistance etc.

Part 4. Gamification in STEM Education

4.3. Examples of Gamification in STEM Education

Labster (2011) is an educational simulation that can be used in several areas ranging from biochemistry to ecology. It addresses different age groups, especially young learners with its game-like graphics and scenarios. It provides students with virtual laboratories at which they can experience the process of an experiment and its particular steps such as designing, manipulating data, analyzing results or arriving at conclusions (Kim et al., 2018).

Another useful tool for gamification in STEM education is CodeCombat (2016). Using a role-playing game, CodeCombat provides students with programming opportunities in the learning environment. Students start with creating a game character to programming and continue with coding to achieve their goals. After completing each task successfully, they receive points and gems that demonstrate the progress of learning. The programming languages of Python, JavaScript, etc. are used in the website and teachers can proceed with creating virtual classrooms to see their students' progress. By using CodeCombat, students can apply various game elements such as unlocking, receiving rewards, completing missions and so on (Kim et al., 2018).

Plantville is among the most frequently used simulation games developed by Siemens (2011). The focus of the game is growing plants to help prospective employees understand industrial management and technologies. Players of the game can start with building and operating a plant. During the game, they explore and experience various roles of a plant manager. At the same time, they try to increase the effectiveness of planting and achieve sustainability throughout the game (Kim et al., 2018).

Part 4. Gamification in STEM Education

4.3. Examples of Gamification in STEM Education

Created as one of the largest tutoring organizations, Kumon (2015) offers ideas for educators on gamifying mathematics. Games such as jump rope and hopscotch can help students practice counting, adding, and multiplying. By following the rules, players can reach higher scores and this means receiving diamond points and extra rewards. Educators can use this effective tool plan for higher grades and more complicated concepts in mathematics, as well (Kim et al., 2018).

Stop Disasters (2007) is a free online simulation game in which learners deal with issues related to natural disasters. Starting with a limited budget, players try to apply disaster prevention methods and emergency precautions for the constructions they build. The game also provides opportunities for players to observe situations caused by natural disasters and after completing the mission, they receive a medal. Flood, earthquake, hurricane and wild fire are among the disaster scenarios to be selected by players (Kim et al., 2018).

Developed by Massachusetts Institute of Technology (2013), The Radix Endeavor is an online multiplayer game for middle and high school students learning algebra, ecology, genetics,

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4.3. Examples of Gamification in STEM Education

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Part 4. Gamification in STEM Education

4.3. Examples of Gamification in STEM Education

Developed by Massachusetts Institute of Technology (2013), The Radix Endeavor is an online multiplayer game for middle and high school students learning algebra, ecology, genetics, geometry, the systems of human body, and statistics. The purpose of the game is to provide learners with self-directed learning experiences with which they can be highly active about solving a problem or collaborating with other players. The game requires the player to complete various quests and while doing it, to collaborate with others as some quests are too difficult to complete alone. With a focus on problem-solving, teachers can easily adapt the game in lessons such as biology and mathematics and they can monitor their students' progress (Kim et al., 2018).

4.4. Educational Game Design Principles

While designing educational games, it is essential to implement some fundamentals.

- Firstly all games should have goals. The goals should be identified in a clear way and gamers should reach it in an immediate way. It should be moderately difficult to attach gamers' motivation alert (Kapp, 2012; Lee and Hammer, 2011).
- It should have challenges that are increased complexity that we call them as levels. Also the challenges and the quests should be clear, concrete and actionable (Deterding, 2013; Lee and Hammer, 2011; Simões, Díaz and Fernández, 2013; Zichermann and Cunningham, 2011).
- It should include personalized experiences, adaptive difficulty that can catch every gamer. Challenges should be perfectly tailored to the players' skill level (Gordon, Brayshaw, and Grey, 2013; Lee and Hammer, 2011; Simões, Díaz and Fernández, 2013; Zichermann and Cunningham, 2011)
- It should present a visible progression and mastery. So points, rewards, levels should be used in a permanent way (Zichermann & Cunningham, 2011).
- There should be an immediate feedback system that shows the right and wrong actions. This will help shape the behavior and the strategies (Lee and Hammer, 2011; Nah, et al., 2014; Zichermann and Cunningham, 2011; Kapp, 2012).
- If there is competition, so there is effort. Competition, corporations and social engagement should be emphasized so the badges, leaderboards, levels, avatars can be helpful for reaching this aim (Deterding, 2013 ;Iosup and Epema, 2014; Simões, Díaz, and Fernández, 2013;Zichermann and Cunningham, 2011).

4.4. Educational Game Design Principles

- The grading should be accrual so the points can help us (Simões, Díaz, and Fernández, 2013).
- The games can get a status which is visible and a sign of reputation and recognition . Again by using points, badges, leaderboards we can succeed (Deterding, 2013; Lee and Hammer, 2011; Simões, Díaz, and Fernández, 2013).
- The content should be accessible (Iosup & Epema, 2014).
- The gamers should be free about their choices and they should be presented to choices, multiple roads that provide chance the gamers to choose their sub-goals within the larger task (Deterding, 2013; Iosup and Epema, 2014;Lee and Hammer, 2011; Simões, Díaz, and Fernández, 2013).
- Gamers should feel free about failing so they should have a chance to attempt in multiple ways (Deterding, 2013; Gordon, Brayshaw, and Grey, 2013; Lee and Hammer, 2011; Kapp, 2012).
- Storytelling, having new identities and roles, time restriction are also the other criterias and factors that are recommended for games (Kapp, 2012; Lee and Hammer, 2011; Nah, et al., 2014; Simões, Díaz, and Fernández, 2013).

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Part 5. Analysis of STEM Education in European Countries

5.1. Quantitative Analysis

For the research Attitude, Knowledge and Application of STEM scale is used as an instrument developed by Wahono and Chang in 2019. The scale includes three domains: STEM attitude, knowledge and application. In this research “attitude” indicates whether the science teacher agrees or disagrees with the application of STEM, at the time of the students’ classroom learning, and the students’ sense of curiosity towards STEM, as well as what is the teacher thinking and feeling about STEM. Knowledge has many specific meanings. In this research, the researchers restricted the term teachers’ STEM knowledge to all information held by a science teacher about STEM education regarding the extent of the term STEM. The knowledge weather STEM education is one kind of teaching method or not, as well as their knowledge of the way to apply STEM in the classroom, including the interconnectedness of one discipline with another. Furthermore, the terms of application, practice, and implementation are words that have the same relative meaning. Those show the meaning of realization or performance of some activities. The term of practice is a real implementation or the usedness of a belief, method, or idea, as opposed to related-theories toward the term. Then, the implementation is the process of putting a decision or plan into effect or execution. In this current research, the researchers would like to use the term application rather than two other words. The term application is more appropriately applied to describe the teacher’s STEM performance in the classroom.

The pilot is carried out with 137 participants who are secondary school science teachers in Indonesia. The internal consistency of the instrument was known from the value of the Cronbach’s Alphas. Three main domains and five subdomains were accessed using this test.

Part 5. Analysis of STEM Education in European Countries

5.1. Quantitative Analysis

The domains were STEM attitude, STEM knowledge, and STEM application. The subdomains were STEM Science-Technology, Science-Engineering, Science-Mathematics, Science-Technology-Engineering, Science-Technology-Math, Science-Engineering-Math, and Science-Technology-Engineering-Math. Then, the next step was validation. In the validation phase, there were two types of validation done. The test is examined by three experts for the validation firstly.

STEM Attitude (SA) explores the information about attitude or respondents' view towards STEM education. The STEM knowledge domain consisted of four question items that were representative of a single construct. The STEM application domain consisted of 23 question items consisting of six constructs. The 23 items were also the result after the reliability and validity test.STEM attitude consisted of three question items that were part of a construct. The scale's internal consistency alpha of all STEM domains was greater than .6. The highest internal value of the highest three domains was in the domain SK (.908) and the lowest value was in the Sap domain (.865). Therefore, the AKA instrument was to be acceptable for internal consistency among domains. The result was that the average expert agreement rate is 83.33%. and at a good level. In terms of the construct validity, exploratory factor analysis was performed by using the IBM SPSS 22.0 for windows program. Based on Hair, Black, Babin, Anderson, and Tatham (2006), only any factors with an eigen value higher than one were included as representative. Then, Kaiser-Meyer- Olkin (KMO) of sampling adequacy test .822 indicating that the variables are highly factorable (Table 4). The result of Bartlett's Test of Sphericity is significant ($p < .05$). The finding indicates that variables were correlated. The Bartlett test was statistically significant and the value of KMO found is higher than the recommended value of .60, and that means the

Part 5. Analysis of STEM Education in European Countries

5.1. Quantitative Analysis

researchers continued the factor analysis. Analysis result of a construct validation using exploratory factor analysis method shows three factors. From the analysis, results obtained information that all items have a factor loading score higher than .5. The largest percentage of variance is in factor one, which is 45.54% of the total variance explained about 77.74%. Finally, using principal component analysis with Varimax Rotation Method items SK1, SK2, SK3, and SK4 were shown to belong to Factor 1. Item SAP_STEM1, SAP_STEM 2, SAP_STEM3 and SAP_STEM4 belong to Factor 2. Then, items SAt1, SAt2 and SAt3 belong to Factor 3. Factor 1 refers to STEM knowledge, factor 2 refers to STEM application and factor 3 refers to STEM Attitude. The results showed that the AKA instrument is valid and can be used to collect data. The AKA instrument allows for collecting quantitative data on a large-scale; and by using an amalgamated instrument, the field now has a baseline to start from, or refer to, for any interventions of STEM education (Wahono and Chang, 2019).

The goal of this application is to clarify the situation of teachers about integrative STEM and to see the differences between five partner countries, Turkey, Greece, Italy, Spain and Romania. Also to discover teachers' views on women's situation in STEM fields. So fort his study researchers prepare and add six more items into the scale such as; In my opinion, female students should be encouraged the STEM fields via using women role models, In my opinion, the situation of women in STEM fields is satisfactory, In my opinion, the number women of working women in STEM fields is enough.

For this reason the internal consistency of the instrument Cronbach's Alphas value is calculated again. The results can be seen below that;

Part 5. Analysis of STEM Education in European Countries

5.1. Quantitative Analysis

Cronbach's Alpha	N of İtems
.955	36

Table 1. Total Cronbach Alpha
As it is seen in Table 1. The total cronbach alpha value is .955 that shows the scale has an internal consistency.

Table 2. Cronbach Alpha Value for Subdimensions

Sub Dimension	Cronbach's Alpha	N of İtems
STEM Attitude	,898	3
STEM Knowledge	,834	4
Science-Tech	,829	4
Science-Engin 321 11.31 2,430 .136	,804	3
Science-Math	,837	3
Application STE	,862	3
Application STM	,859	3

Part 5. Analysis of STEM Education in European Countries

5.1. Quantitative Analysis

Table 2. Cronbach Alpha Value for Subdimensions

Sub Dimension	Cronbach's Alpha	N of İtems
Application SEM	,794	3
Application STEM	,893	4
Role Model	,851	6

As it is seen on Table 2. All the cronbach alpha values are bigger than.80 so the correlation coefficient is very high because it is between 80 and 100 denoting that a strong relationship exists between the targeted variables (Best and Kahn, 2006).

After reliability analysis; it is checked whether the data is distributed normally or not by using skewness and kurtosis values. It is seen that according to the skewness and kurtosis value, the data that is normally distributed. These values range from -.811 to 2.95. There are studies that reported normal distribution in the range of -3 -3 in the skewness-kurtosis values (Matis, Birbilis and Kontogianidis, 2009; Slate and Rojas-Lebouef). Because of this parametric tests are used in the study.

Part 5. Analysis of STEM Education in European Countries

5.1. Quantitative Analysis

Table 3. STEM Scale and Its Sub-Dimensions' Arithmetic Mean, Standard Deviation and Standard Error Values

Dimensions	N	X	ss	Shx
Attitude	321	12.2	2.4	1.3
STEM Knowledge	321	15.4	3.1	.17
Science-Tech	321	15.4	3.0	.17
Science-Engin	321	11.3	2.4	13
Science-MATH	321	11,5	2,3	131
App STE	321	11,4	2,3	133

Part 5. Analysis of STEM Education in European Countries

5.1. Quantitative Analysis

Table 3. STEM Scale and Its Sub-Dimensions' Arithmetic Mean, Standard Deviation and Standard Error Values

Dimensions	N	X	ss	Shx
AppSTM	321	11.8	2.4	1.3
AppSEM	321	11.5	2.2	.12
AppSTEM	321	15.2	2.9	.16

Part 5. Analysis of STEM Education in European Countries

5.1. Quantitative Analysis

For Checking the Differentiation Status of According to Country Variable
One-Way Variance Analysis (ANOVA) was used.In all subdimensions and according to total points, the difference is meaningful statistically. The points differ according to the country variable. To see the differences in a detailed way, the post hoc test Tamhane's T2 test is used because the variances aren't homogene ($p<.01$)
According to the Tamtest T2 results;

- In Attitude dimension; there is a difference between Italy and Greece. Attitude points of teachers' in Italy are higher than the attitude points of teachers in Greece. ($p<.01$) Teachers' attitude points in Greece are lower than Spain and Romania's teachers' attitude points too ($p<.01$). There are no meaningful differences of teachers' attitude points in Turkey with other countries.
- In the Knowledge dimension, teachers' knowledge points in Italy are higher than teachers' knowledge points in Greece, Spain and Romania ($p<.01$). Teachers' knowledge points in Italy are higher than teachers' knowledge points in Turkey too ($p<.05$).
- In the ScienceTech dimension teachers' points in Italy are higher than teachers' points in Greece, Romania and Turkey ($p<.01$). Teachers' points in Italy are higher than teachers' points in Spain too ($p<.05$). In the ScienceTech dimension teachers' points in Romania are higher than teachers' points in Greece too ($p<.05$).
- In the Science Engine dimension; teachers points in Italy are higher than Greece, Spain, Romania and Turkey's teachers points. The difference is meaningful at .01 level.
- In ScienceMath dimension, teachers' points in Italy are higher than in Greece, Spain, Romania and Turkey's teachers' points. The difference is meaningful at .01 level.
- In the AppSTE dimension teachers points in Italy are higher than in Spain, Romania and teachers points in Turkey. The difference is meaningful at .01 level. Teachers points in Italy are higher than teachers points in Greece too. The difference is meaningful at .05 level.
- In the AppSTM dimension teachers points in Italy are higher than teachers' points in Greece and Romania. The difference is meaningful at .01 level. Teachers points in Italy are higher than teachers points in Spain and Turkey. The difference is meaningful at .05 level. Also teachers points in Romania are higher than teachers' points in Greece. The difference is meaningful at .05 level.

Part 5. Analysis of STEM Education in European Countries

5.1. Quantitative Analysis

- In the AppSEM dimension teachers' points in Italy are higher than Greece, Spain, Romania and Turkey. The difference is meaningful at .01 level.
- In the AppSTEM dimension teachers points in Italy are higher than Greece, Spain and Romania. The difference is meaningful at .01 level. Teachers points in Italy are higher than teachers points in Turkey too and the difference is meaningful at .05 level.
- In AppTotal teachers' points in Italy are higher than Greece, Spain, Romania and Turkey. The difference is meaningful at .01 level.
- Role Model points of teachers in Italy are higher than role model points of teachers in Greece ($p<.01$). Role Model points of teachers in Spain are higher than role model points of teachers in Greece ($p<.05$). Role Model points of teachers in Romania are higher than role model points of teachers in Italy, Greece, Spain ($p<.01$).Also Role Model points of teachers in Turkey are higher than role model points of teachers in Italy, Greece and Spain ($p<.01$).
- Also STEM Scale total scores Tamhane T2 results are counted to examine the differences between countries. In Total the points of teachers in Italy are higher than the points of teachers in Greece and Spain ($p<.01$) The total points of teachers in Romania are higher than the total points of teachers in Greece ($p<.01$) and Spain ($p<.05$). There are no meaningful differences among Turkey and other countries in terms of total points statistically.

Part 5. Analysis of STEM Education in European Countries

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Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

- **Turkey**

1. Qualifications/attributes for being a role model in STEM fields? Why?

Theme	Category	Code
Qualifications/attributes for being a role model	Attitudes	• Dedication • Pursuit of innovation • Professional development
	Skills	• A mindset for professional development • Creativity • Finding solutions to real life problems • Analytical thinking • Using STEM materials effectively • Putting theory into practice • Having a multidisciplinary perspective
	Interests	• Innovation • Information technologies • Research • Design • Productivity
	Knowledge base	• Master in STEM • Good content knowledge • Good technology knowledge

Part 5 Analysis of STEM Education in European Countries

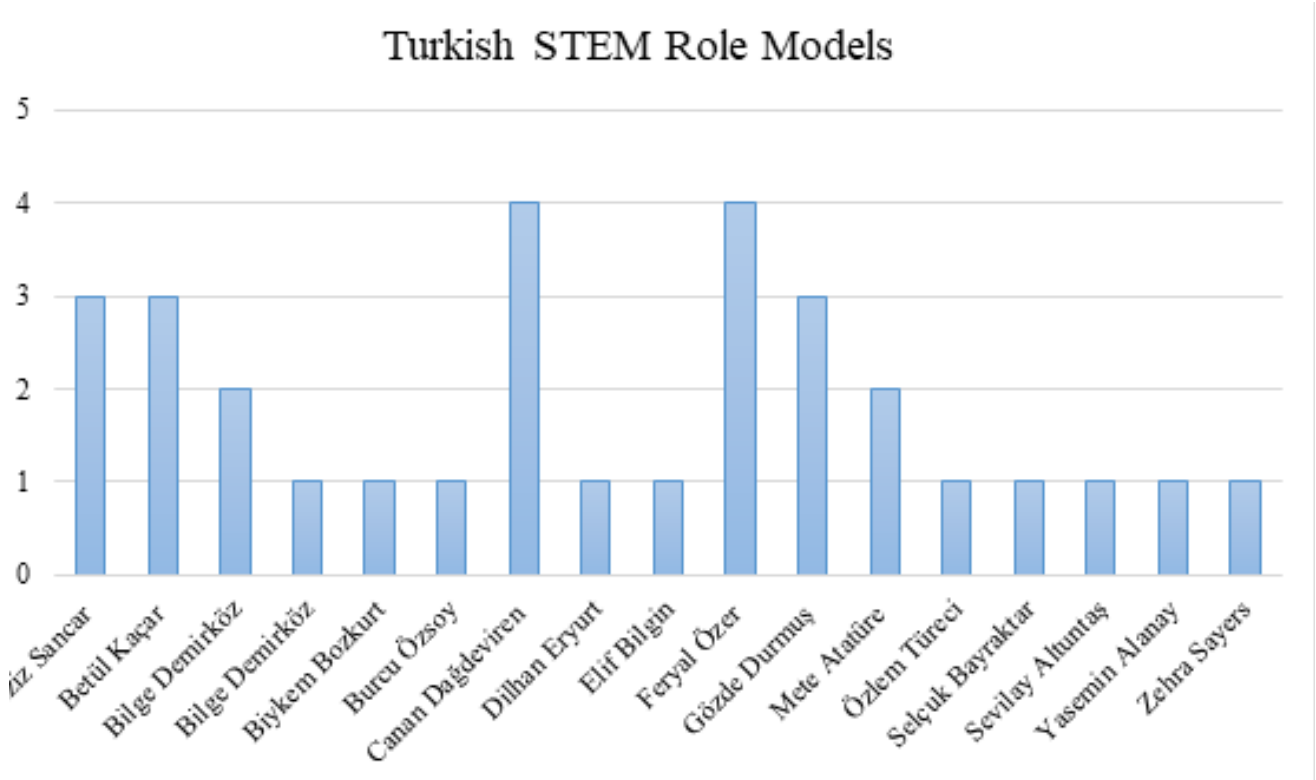
5.2. Qualitative Analysis

Turkey

“First of all, being a role model in STEM requires being awareness of technology literacy ,then must be creative and have a large perspective.The person must have have the ability of designing, producing, a good searcher , an examiner and try to find a way out of a problem.A role model must have analytical thinking and put into practise theoretical knowledge.
” (P8)

“To be master of the information technology, science, mathematics and to like information technology. Because STEM contains something special and interesting.” (P4)

2. Who are the role models in STEM fields in your country?



Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Turkey

Theme	Category	Code
Role models in Turkey	Science	• Feryal Özel • Betül Kaçar • Aziz Sancar • Bilge Demirköz • Gözde Durmuş • Biykem Bozkurt • Özlem Türeci • Mete Atatüre • Dilhan Eryurt • Yasemin Alanay • Sevilay Altuntaş • Elif Bilgin • Zehra Sayers
	Engineering	• Canan Dağdeviren • Burcu Özsoy • Selçuk Bayraktar

“Dr. Canan Dağdeviren is a doctor who has a lab in MIT, Feryal Özer is an astrophysicist in NASA, Gözde Durmuş is a scientist and geneticist in Stanford University.” (P6)

“Aziz SANCAR is Turkish biochemist and molecular biologist specializing in DNA repeair, cell cylcle checkpoints and circadian clock. He has awarded the 2015 Nobel Prize in Chemistry.” (P5)

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Turkey

3. What do you think about the situation of women in STEM fields in your country?

Theme	Category	Code
The situation of women in STEM fields	Positive thoughts	• Having successful scientists • The increasing number of women in STEM • No discrimination between male and female • Empowering women to pursue career • Encouraging women entrepreneurs
	Negative thoughts	• Not known by the community • Not enough in number • No equal access to education • Cultural differences
	Neutral thoughts	• Depends on the region • Equal opportunities for each gender

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

- “The number of scientists is increasing day by day in our country. Today, it is observed that they find more comfortable working environments and take an active role in every segment of the society.” (P3, ..., ...)

- “Turkish women are not in a good position to access education in general .Researches show that women are eager to be ın STEM fields and the number of female students who want to be educated in this field is growing day by day. Unfortunately,because of social inequality women can not rise as quickly and easily as men.”(P7, ..., ...)

- 4. Do you think that the number of women working in/studying at STEM fields is sufficient in your country? Why?

Theme	Category	Code
The number of women in STEM fields	Sufficient	• Promising number • Increasing popularity
	Insufficient	• The need to have more scientists • Lack of investment • Not educating girls • Not having awareness • Gender discrimination • Limited opportunities • Societal expectations • Traditions • Role of women at home

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

- “I think it is gaining popularity in the field of Stem day by day. Of course we can not say that the amount of women in Stem are improving rapidly.” (P8, ..., ...)

- “No, I absolutely don’t think the number of women working in/ studying at STEM fields is sufficient. First of all, we can’t deny the fact that gender discrimination hasn’t been totally eliminated from society in Turkey. In my opinion, that is an important fact which affects the number of women working in/ studying at STEM fields.” (P6, ..., ...)
- **5. How can we encourage female students to STEM fields ?**

Theme	Category	Code
Ways to encourage female students to STEM fields	Actions	• Introducing role models • Providing support and opportunity • Providing trainings and courses • Raising awareness • Helping them believe in themselves • Creating an environment like laboratories • Inspiring them
	Precautions	• Eliminating gender discrimination • Introducing females students to science at a younger age • Managing HR effectively

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

- “We should introduce role model Turkish Female Scientists to female students in a good way ,they should see them at school, TV, in the magazines, on the street billboard frequently, so that they can get to know them well and inspire from them. I think that the most effective tool in this may be television and school environment” (P1, ..., ...)
- “First step could be eliminating gender discrimination. Introducing young female students to STEM values at a younger age could also be an option to encourage female students to STEM fields.” (P8, ..., ...)

6. What are the popular STEM tools in your country? Why?

Theme	Category	Code
Popular STEM tools in Turkey	Technological devices	• Mobile phones • Experiment equipment • Computers • Kits for STEM activities • Robotics equipment • Arduino sets • Tablets • Applications (Google Earth etc.) • Softwares • Coding tools
	Published materials	• Books • Articles • Lesson plans
	Materials	• Recycling materials • Old stuff
	Education models	• Harezmi Education Model

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Theme	Category	Code
Popular STEM tools in Turkey	Events	• Fairs • Activities • Exhibitions

- “The easiest way to access information about science and technology is the mobile phones in our hands and the internet .” (P1,..., ...)
- “Books, articles, lesson plans, experiment equipment, technological devices such as computers, smart phones, kits for stem activities, robotics equipment etc...” (P2, ..., ...)
- “...You can use many things as STEM tools. Recycling materials, old stuff which can not use regularly anymore...”. (P3, ..., ...)
- “There are some science fairs and activities which are produced by public governments and local municipalities. These fairs are very suitable as a STEM tools.” (p5, ..., ...)

7. What kind of tools have you used in the STEM fields so far? Do you think they are effective or not? Why?

Theme	Category	Code
Effective STEM Tools	Technological devices	• Computers • Smart phones • Arduino • M Block (Scratch) • C++ • Autodesk Tinkercad • IBM ML • Simulation • Videos • Interactive whiteboard • Artificial intelligence • Internet

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Theme	Category	Code
Effective STEM Tools	Published materials	• Stem lesson plans, • Source books for stem activities • Survey • Graphics • Vocabulary games
	Experiments	• Robotic activities, • Energy activities, • Wearable technology

“I used Arduino sets and also programmed with M Block (Scratch) and C++. For designing I used Autodesk Tinkercad online platform. Also I used for machine learning IBM ML for kids online platform. ” (P3, ..., ...)

“I have used Stem lesson plans, source books for stem activities”. (P2, ..., ...)

In our school, we have a STEM clup. We make STEM activities during six hours every week. It gives many opportunities to students and teachers.

We make robotic activities, energy activities, wearable technology and particular workshops.(P5, ..., ...)

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

8. What do you think about the qualifications of an effective e STEM material?

Theme	Category	Code
Qualifications of an effective STEM material	Use	• Easy use • Easy access • Free of charge • Up-to-date • Interactive use • Integration of artistic structures
	Attributes	• Functional • Motivating • Covering at least three STEM fields (multifunct
	Target Skills	• Critical thinking • Creativity • Productivity • Problem solving

“An effective STEM material is easy to use, free of charge or available with low price and can be used in multiple projects” (P3, …, …)

“I think it should be effective enough to inspire students to think critically, find creative solutions to everyday problems”.(P6, …, …)

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Greece

1. Qualifications/attributes for being a role model in STEM fields? Why?

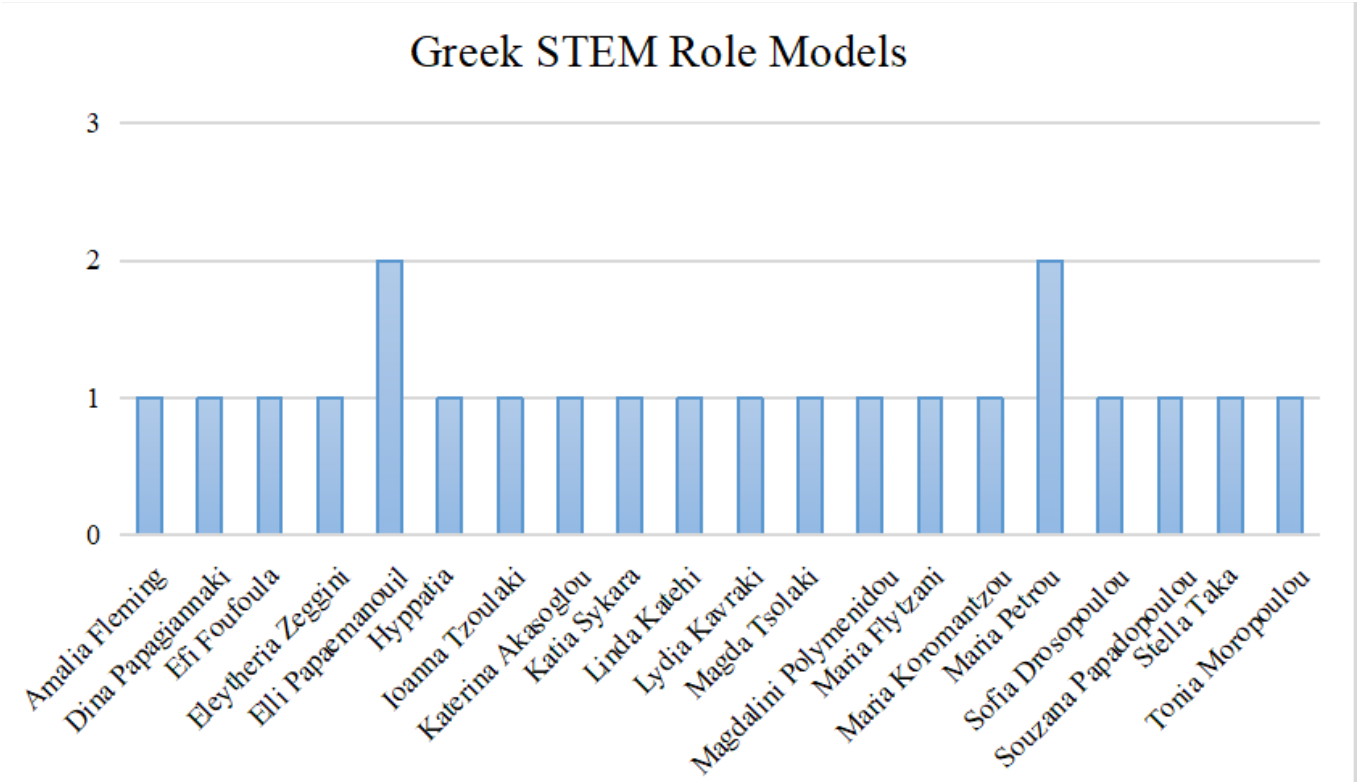
Theme	Category	Code
Qualifications /attributes for being a role model	Skills	• Being a stem communicator • Transferring stem knowledge to people
	Achievements	• Having an important position in academia • Having an important invention • Having an important prize • Having an invention named after you • Performing important research • Performing important publication • Having a good public appearance
	Knowledge Base	• Expertise in a STEM field, • Proved excellency and work done in a STEM field
	Charachteristics	• Inspiring others • Hardworking • Dedicated • Leadership • Strong • Independent

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Greece

2. Who are the role models in STEM fields in your country?



Theme	Category	Code
STEM Role models in Greece	Science	• Eleytheria Zeggini • Elli Papaemanouil • Magdalini Polymenidou • Tonia Moropoulou • Amalia Fleming • Maria Koromantzou • Ioanna Tzoulaki • Katerina Akasoglou • Maria Petrou • Magda Tsolaki • Stella Taka
	Technology	• Lydia Kavraki • Katia Sykara • Sofia Drosopoulou

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Greece

2. Who are the role models in STEM fields in your country?

Theme	Category	Code
STEM Role models in Greece	Engineering	• Efi Foufoula • Maria Flytzani • Linda Katehi
	Mathematics	• Hyppatia • Souzana Papadopoulou

3. What do you think about the situation of women in STEM fields in your country?

Theme	Category		Code
The situation of women in STEM fields	Positive Thoughts		• Active women in certain fields (e.g. architecture, biology, medicine etc.) • Improving situation in gender equality
	Negative Thoughts		• Male-dominated • Few opportunities for girls • Gender discrimination • House working mother as a role model • Society prejudice • Low visibility • Difficult to make a name in STEM • Fixed mindset • No state policy to empower girls

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Greece

"Girls are not good in math", "women in science? It's a joke, they should look very ugly", "women should look beautiful, should not be smart" are only a few phrases signifying the average male (but unfortunately also female) perception of women in STEM in Greece. (P7)

4. Do you think that the number of women working in/studying at STEM fields is sufficient in your country? Why?

Theme	Category	Code
The number of women in STEM fields	Sufficient	• No huge gender gap in studying • Enough for inferior position • Good in some chemist labs or medicine facilities
	Insufficient	• Gender gap • Gender gap in academia/workplace • Less women in leading positions • Lack of role models • Prejudice of the society • Quitting career after giving birth • Man dominated STEM fields

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Greece

5. How can we encourage female students to STEM fields ?

Theme	Category	Code
Ways to encourage female students to STEM fields	Actions	• Encouraging girls to STEM fields at school • Introducing role models • Organizing events to encourage female students • Imprinting success stories in girls' minds • Changing the beliefs of parents • Changing the beliefs of the society • Telling stories to girls about successful women in STEM • Treating boys and girls equally • Talking about students' prejudices they bring from home, TV etc. • Giving examples about facing challenges
	Precautions	• Stop thinking in boxes • Changing the attitudes of others

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Greece

6. What are the popular STEM tools in your country? Why?

Theme	Category	Code
Popular STEM tools in Greece	Technological devices	• Robotic kits • Robotic lego kits • Mindcraft • PhET • Online materials • videos
	Published materials	• Books
	Other	• Quiz games • Whiteboards • Exercises • Experiments

7. What kind of tools have you used in the STEM fields so far? Do you think they are effective or not? Why?

Theme	Category	Code
Effective STEM Tools	Digital Tools	• PhET • Robotic kits • Mindcraft • Computer
	Non-digital Tools	• Experiments • Quizzes • Games

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Greece

8. What do you think about the qualifications of an effective STEM material?

Theme	Category	Code
Qualifications of an effective STEM material	Use	• Nice appearance • Bringing knowledge • Experiential • Learning by doing • Learning by playing
	Attributes	• Surprising • Solid • Well-structured • Appealing • Exciting students • Motivating

Part 5 Analysis of STEM Education in European Countries

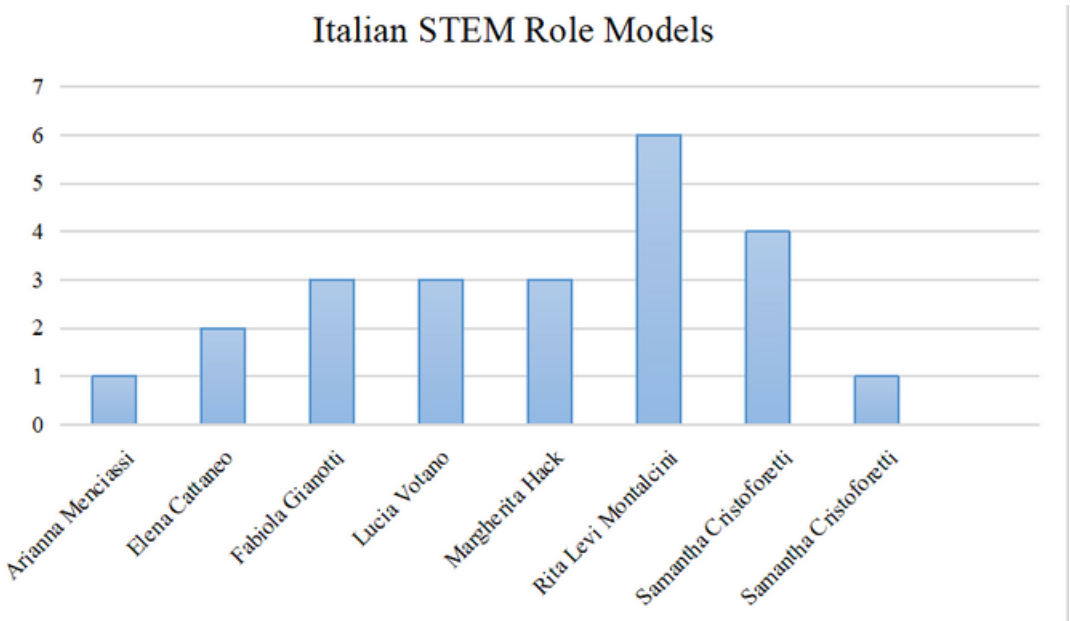
5.2. Qualitative Analysis

Italy

1. Qualifications/attributes for being a role model in STEM fields? Why

Theme	Category	Code
Qualifications/attributes for being a role model	Achievments	• Prize • Important position in the academia • Important research • Important publication • Good career • Good life • Good public appearance
	Charachteristics	• Strong • Independent • Dedicated • Grateful • Committed • Hardworking

2. Who are the role models in STEM fields in your country?



Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Italy

Theme	Category	Code
Role models in Italy	Science	• Lucia Votano • Rita Levi Montalcini • Fabiola Gianotti • Margherita Hack • Elena Cattaneo
	Engineering	• Samantha Cristoforetti • Arianna Menciassi

3. What do you think about the situation of women in STEM fields in your country?

Theme	Category	Code
The situation of women in STEM fields	Positive thoughts	-
	Negative thoughts	• Burden • Motherhood • Leaving the job • Few opportunities for girls • Man-dominated • No women collaboration • Few in the workplace

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

“I believe that in Italy there are few in the workplace and many who undertake these studies. In fact we have many capable girls in STEM but it is difficult for them to overcome the prejudices of society for their role, often the potential does not count but the sex. The woman in a company is increasingly problematic, because there is the possibility that she becomes a mother and therefore forms a family.” (P5,)

4. Do you think that the number of women working in/studying at STEM fields is sufficient in your country? Why?

Theme	Category	Code
The number of women in STEM fields	Sufficient	Universities
	Insufficient	• Workplace • Not enough • Few women • No boss roles • No women in computer companies

5. How can we encourage female students to STEM fields ?

Theme	Category	Code
Ways to encourage female students to STEM fields	Actions	• Showing examples • Providing behavior patterns • Showing success stories • Encouraging girls
	Precautions	• Avoiding gender discrimination • Preventing societal prejudices

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

6. What are the popular STEM tools in your country? Why?

Theme	Category	Code
Popular STEM tools in Italy	Technological Devices	• Internet • Videos • Presentations
	Materials	• Books • Exercises • Experiments

7. What kind of tools have you used in the STEM fields so far? Do you think they are effective or not? Why?

Theme	Category	Code
Popular STEM tools in Italy	Technological Devices	• Internet • Videos • Presentations
	Materials	• Books • Exercises • Experiments

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

8. What do you think about the qualifications of an effective e STEM material?

Theme	Category	Code
Qualifications of an effective STEM material	Use	-
	Attributes	• Effective • Amazing • Capture attention • Exciting • Thrilling
	Target Skills	-

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Spain

1. Qualifications/attributes for being a role model in STEM fields? Why?

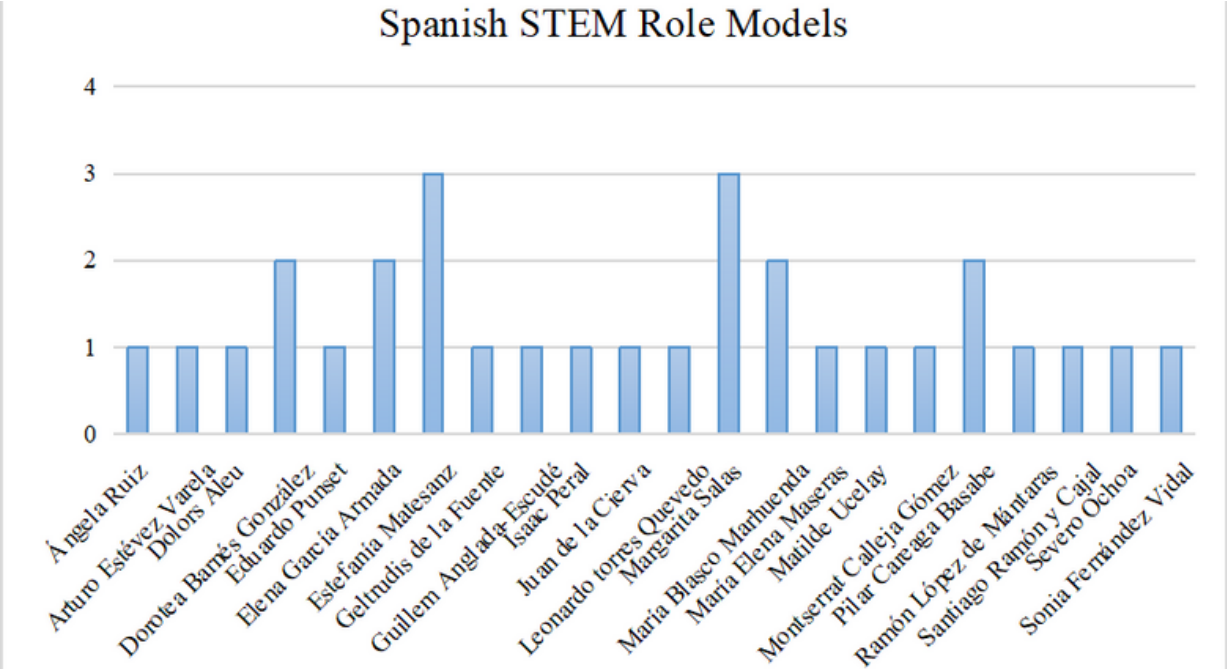
Theme	Category	Code
Qualifications/attributes for being a role model	Skills	• Generosity • Using technology effectively • Being innovative • Updating knowledge • Continuity in studies • Following scientific research procedures • Taking initiatives
	Knowledge Base	• Being an expert in the field • Having good knowledge base • Having practical experience
	Charachteristics	• Creative • Ingenious • Multifaceted • Analyst • Curious • Collaborator • Deterministic • Patient • Precise • Optimistic • Passionate • Persistent

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Spain

2. Who are the role models in STEM fields in your country?



Theme	Category	Code
Role models in Spain	Science	• Guillem Anglada-Escudé • Montserrat Calleja Gómez • Dorotea Barnés González • Santiago Ramón y Cajal • Severo Ochoa • María Blasco Marhuenda • Margarita Salas • Eduardo Punset • Sonia Fernández Vidal • Geltrudis de la Fuente • María Elena Maseras
	Technology	• Arturo Estévez Varela • Juan de la Cierva • Estefanía Matesanz • Pilar Careaga Basabe • Isaac Peral

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Theme	Category	Code
Role models in Spain	Engineering	• Arturo Estévez Varela • Juan de la Cierva • Estefanía Matesanz • Pilar Careaga Basabe • Isaac Peral • Matilde Ucelay

3. What do you think about the situation of women in STEM fields in your country?

Theme	Category	Code
The situation of women in STEM fields	Positive Thoughts	• Many women • Women with same opportunities with men • Possessing the necessary attributes • Women occupying important positions in stem fields • Increasing number of women • Good number of women in health • Better than previous years
	Negative Thoughts	• Insufficient number of women • No early incorporation of women to stem fields • Societal beliefs • Far from gender equality • Stem positions reserved for men • A long way to go • Limited number of women in mathematics, engineering, technology • Still a lot of work to do

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

4. Do you think that the number of women working in/studying at STEM fields is sufficient in your country? Why?

Theme	Category	Code
The number of women in STEM fields	Sufficient	• In progress • In 10 years' time
	Insufficient	• Should be more women • Not attractive for Spanish women • Subject to improvement • Societal beliefs • A long way to go • Need balance

5. How can we encourage female students to STEM fields ?

Theme	Category	Code
Ways to encourage female students to STEM fields	Actions	• Raising awareness • Informing society • Conducting campaigns • Highlighting the figure of women in stem fields • Offering women experiences • Highlighting the obstacles • Scaffolding girls • Getting to know the trajectory of relevant women in the stem field • Inviting role models to schools
	Precautions	• Ensuring equality of genders • Eradicating macho stereotypes

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

6. What are the popular STEM tools in your country? Why?

Theme	Category	Code
Popular STEM tools in Turkey	Technological Devices	• Internet • Social networks • Robotics
	Materials	• Laboratory equipment
	Education Models	• Courses • Studies • Universities
	Events	• Conferences

7. What kind of tools have you used in the STEM fields so far? Do you think they are effective or not? Why?

Theme	Category	Code
Effective STEM Tools	Technological Devices	• Software • Forums • Computer • Telecommunication tools • Social networks • Robotics • 3D printers • Programming • Video games

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

8. What do you think about the qualifications of an effective e STEM material?

Theme	Category	Code
Qualifications of an effective STEM material	Use	• Safety • Easy use • Low cost
	Attributes	• Accessible • Standardized • Approved • Supported by tests • Durability
	Target Skills	• Teamwork • Creativity • Helping each other • Collaboration •
	Events	• Conferences

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Romania

1. Qualifications/attributes for being a role model in STEM fields? Why?

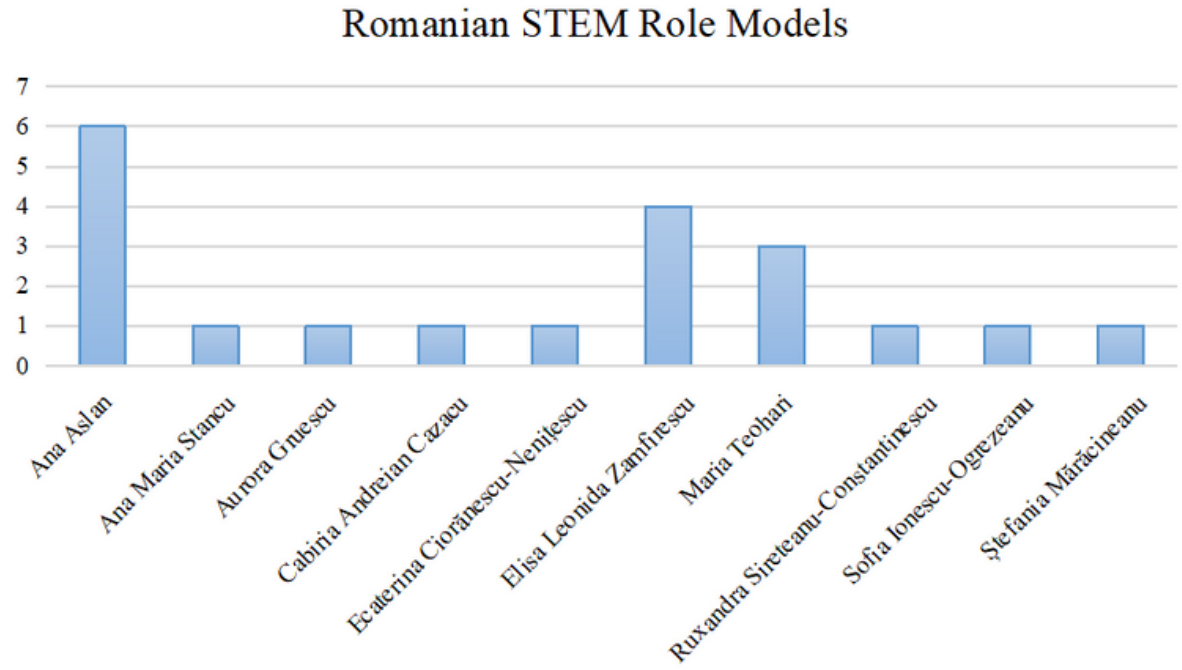
Theme	Category	Code
Qualifications/attributes for being a role model	Achievements	• Invention 4 • Development of products • Prize 2 • Sustained research • High publication • Contributing to the field • Work power
	Qualifications	• Specialization in STEM fields • Transdisciplinary studies • High qualification
	Charachteristics	• Brave • Involved • Vision in the field • A recognized leader in the professional / academic world • Inspirational • Motivating • Innovative • Imagination • Rigor • Desire for self-sufficiency

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Romania

2. Who are the role models in STEM fields in your country?



Theme	Category	Code
Role models in Romania	Science	• Ana Aslan • Maria Teohari • Sofia Ionescu-Ogrezeanu
	Technology	• Ana Maria Stancu
	Engineering	• Elisa Leonida Zamfirescu • Aurora Gruescu
	Mathematics	• Cabiria Andreian Cazacu • Ecaterina Ciorănescu-Nenițescu • Ștefania Mărăcineanu • Ruxandra Sireteanu-Constantinescu

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Romania

3. What do you think about the situation of women in STEM fields in your country?

Theme	Category	Code
The situation of women in STEM fields	Positive Thoughts	• Encouragement to participate • Access to education • Access to technology • Rapid globalization • Highest percentage of women in technology (Romania) • Gradual increase in women's number in STEM fields
	Negative Thoughts	• Underrepresented • Gender differences • Slow advancement • Lack of support • Numerical domination of men • Lack of female solidarity

4. Do you think that the number of women working in/studying at STEM fields is sufficient in your country? Why?

Theme	Category	Code
The number of women in STEM fields	Sufficient	• Gradual increase in women's number in STEM fields • Increasing number in IT field
	Insufficient	• Not equal in all areas • Orientation of females to humanistic directions • Low number in physics, chemistry etc. • Gender limitation • Cultural barriers • Lack of educational policies

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Romania

5. How can we encourage female students to STEM fields ?

Theme	Category	Code
Ways to encourage female students to STEM fields	Teaching Practices	• Creating different and interesting experiences for girls • Helping girls exploring technology in an interactive and intuitive way • Providing girls with practical knowledge • Arousing curiosity • Encouraging students with experiments • Promoting successful models • Developing hands-on training • Encouraging project-based learning • Encouraging students to express their opinions properly • Promoting young students in rural areas
	Educational Policies	• Promoting student career discovery programs • Gaining public support • Financial support to STEM programs • Promoting mentoring programs • Presenting successful careers • Encouraging girls' participation in scientific events

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Romania

“Promoting successful models is a good method of encouragement. The power of the example stimulates motivation, causing women to believe in their abilities and the fact that they can reach the success that others have not been able to achieve.”(P3)

6. What are the popular STEM tools in your country? Why?

Theme	Category	Code
Popular STEM Tools in Romania	Traditional Tools/Approaches	• Experiential learning • Exploration • Investigation • Overall thinking • Promoting interaction • Team activities • Arousing the imagination and inspiration of students
	Non-traditional Tools/ Approaches	• Integrating all stem fields into a cohesive learning paradigm • Integration of technology • Interdisciplinary approach • Transdisciplinary approach • Use of virtual learning environments

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Romania

7. What kind of tools have you used in the STEM fields so far? Do you think they are effective or not? Why?

Theme	Category	Code
Effective STEM Tools	Technological Tools	• IT tools • Applications • Robotics • Mindcraft • Scratch • Hour of code • Introducing technology
	Non-Technological Tools	• Introducing engineering • Inviting stem people • Having practical lessons • Introducing female role models • Exploration 2 • Discovering the world • Investigation 2 • Learning to learn • Modern teaching methods

Part 5 Analysis of STEM Education in European Countries

5.2. Qualitative Analysis

Romania

8. What do you think about the qualifications of an effective e STEM material?

Theme	Category	Code
Qualifications of an effective STEM material	Student Dimension	• Promoting curiosity • Reinforcing creativity • Improving motivation • Developing cognitive skills • Solving problems • Stimulating critical thinking • Fostering 21st century skills
	Curriculum Dimension	• Achieving its purpose • Achieving objectives in the curriculum • Alignment of the material with the curriculum • Extra-curricular activities • Hands-on activities • Experiments
	Teacher Dimension	• Encouraging teachers • Providing teacher training

Part 6. Results and Recommendations

- There is a huge gender gap in STEM areas against girls in many parts of the world. According to Wood (2020), only 30 % of researchers in STEM areas are women all around the world. Many countries are struggling to fill this gap and are developing policies to reverse this ongoing trend as more and more workforce will be necessary in STEM areas and there will be a demand for skilled workers in the aforementioned areas (Magwood, 2017).

- The reasons for underrepresentation of women in STEM areas based on three factors; stereotype threat, lack of interest and lack of role models. So the role models should be emphasized in STEM education.

- We can categorize the materials used in these studies as;

1. Simple Materials: Materials that are often used as auxiliary, easy to find, and easy accessible. For example: pen, paper, ruler, cardboard, scissors, pipette, paint, bottle, silicone, simple electrical circuit elements, laboratory supplies, food, recycling materials.
2. Technological Materials: The materials which are supported technologically. For example: arduino, raspberry pi, sensors, 3D printer, filament, computer, robot kits.
3. Published Materials: Graphics, chart visuals, lesson plans etc.
4. Training Kits: Kits made of various materials like wooden, lego, plastic etc. without coding and software and non-printed play sets.
5. Computer Programs: They are handled under two headings;

a. Software and coding programs: Include programs with coding. For example: Mblock,, Scratch program, Lego Education EV3 program

b. Other programs: Programs that do not require coding (Simulations, animations, video and audio editing programs, drawing programs) For example: Tinkercad, Google Sketchup (3D modeling program), Movie Maker (video editing program), Algodoo, Powtoon (animation and video production program)

Part 6. Results and Recommendations

- 6.Games; that are handled under two headings. Online or other games (published, game kits etc).
- From these materials simple materials, technological materials and the computer programsa are used mostly while games are used less. So the gamification has the potential to enhance the STEM education.
- Women can be leaded to STEM fields with some special interventions especially by using role-models. Role models are important to motivate women because role models demonstrate them particular goals, the ways and conveys the message if you follow these ways so you can success. Also role models reduces the stereotype threat so develop the performance. Exposuring male models decrease the women interest, belonging and perceived success. On the other hand exposure to female role models increases womens's self concept and positive attitudes on STEM fields. A relevant role model help students to attain identities and perceive a strong connection with future. So recent studies put forward that thinking about the future and feeling connected to someone's experiences plays an important role on college academic achievment.
- While choosing role models there are some points that should be taken into consideration. These are;

- 1. A sense of perceived similarity to the role model: If students perceive the role models' life, actions, thoughts etc. similiar to themselves, they behave positively to that career, feel self-efficacy and demonstrate success. This similarity is not an objective one but a perceived one also this type of similiarity. So to increase the effectiveness the role models should be choosen who are higly similiar to students with their attitudes, values etc. Also it may be useful to concentrate on role models' efforts (Drury, Siy and Cheryan, 2011). According to the social learning theory, psychological studies and empirical researches suggest that students prefer to have role models whose race and gender are the same as their own as well as who share similiar demographics and interests (He, Murphy, and Luo, 2016).

Part 6. Results and Recommendations

- 2.Role models and learning opportunities should focus to create access as well as build confidence in females to pursue their interests in STEM carreers (Weber, 2011).
- 3.The role models must be perceived as competent (Marx and Ko, 2012; Marx, Monroe, Cole and Gilbert, 2013)
- 4.Individuals must realize the success and the actions of role model in the mutual area of interest and direct contact with a role model is not necessary (Marx and Roman, 2002).
- 5.Individuals should be asked to think about their current academic situation and evaluate their relations or conversations with the role-models in this way. If they think about the future and their “best self” role model can lead discouragement that the individuals assessed their current ability so the role model’s achievments seem unattainable. Thus it is very important that role models underlined the challenges that they have experienced so far (Adelman, Herrmann Bodford, Graudejus, Okun and Kwan, 2016)
- 6.Role models should describe overcoming challenges, normalize feelings of not belonging, and emphasize the importance of college degree (Adelman, Herrmann, Bodford, Graudejus, Okun and Kwan, 2016)
- 7.Cheryan et al (2011) found that role model should be appropriate to stereotypes.For example for Computer scientists the stereotype is as “computer nerds” who are socially awkward and obsessed with computers (Margolis and Fisher, 2002; Schott and Selwyn, 2000).
- 8.Role models should share information what day in the life of them like, what studies they undertook, how difficult those are, what they like to do in addition to their study or work and with whom (Booy et.al,, 2012).
- 9.Role models should be the one who have educational backgrounds in STEM and now enjoying their job in STEM fields (Booy et.al., 2012).

Part 6. Results and Recommendations

- Gamification has a potential to increase students' motivation. Many educators complain about motivational problems in their classes and gamification can be used as a tool to foster students' motivation, active participation, and engagement in the learning environment (Domínguez et al., 2013).
- While designing educational games, it is essential to implement some fundamentals.
- 1.Firstly all games should have goals. The goals should be identified in a clear way and gamers should reach it in an immediate way. It should be moderately difficult that can attach gamers' motivation alert (Kapp, 2012).
- 2.It should have challenges that are increased complexity that we call them as levels. Also the challenges and the quests should be clear, concrete and actionable (Deterding et.al, 2013; Lee and Hammer, 2011; Zichermann and Cunningham, 2011).
- 3.It should include personalized experiences, adaptive difficulty that can catch every gamer. Challenges should be perfectly tailored to the players' skill level (Gordon, Brayshaw, and Grey, 2013; Lee and Hammer, 2011; Zichermann and Cunningham, 2011)
- 4.It should present a visible progression and mastery. So points, rewards, levels should be used in a permanent way (Zichermann & Cunningham, 2011).
- 5.There should be an immediate feedback system that shows the right and wrong actions. This will help shape the behaviour and the strategies (Lee and Hammer, 2011; Nah, et al., 2014; Zichermann and Cunningham, 2011; Kapp, 2012).
- 6.If there is competition, so there is effort. Competition , corporations and social engagement should be emphasized so the badges, leaderboards, levels, avatars can be helpful for reaching this aim (Deterding et. al., 2013 ;Iosup and Epema, 2014; Zichermann and Cunningham, 2011).

Part 6. Results and Recommendations

- 7.The grading should be accrual so the points can help us (Simões, et al., 2013).
- 8.The games can get a status which is visible and a sign of reputation and recognition . Again by using points, badges, boards, we can succeed it (Deterding, 2013; Lee and Hammer, 2011; Simõe et. al., 2013).
- 9.The content should be accessible (Iosup & Epema, 2014).
- 10.The gamers should be free about their choices and they should be presented to choices, multiple roads that provide cahnce the gamers to choose their sub-goals within the larger task (Deterding, 2013; Iosup and Epema, 2014;Lee and Hammer, 2011).
- 11.Gamers should feel free about failing so they should have chance to attempt in multiple ways (Deterding, 2013; Gordon, Brayshaw, and Grey, 2013; Lee and Hammer, 2011; Kapp, 2012).
- 12.Storytelling, having new identities and roles, time restriction are also the other criterias and factors that are recommended for games (Kapp, 2012; Lee and Hammer, 2011; Nah, et al., 2014; Simões, et.al., 2013).

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